

REASONING IN WHITE RATS

BY
NORMAN R. F. MAIER

A DISSERTATION

SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR
THE DEGREE OF DOCTOR OF PHILOSOPHY IN THE
UNIVERSITY OF MICHIGAN

(Reprinted from COMPARATIVE PSYCHOLOGY MONOGRAPHS, Vol. 6, No. 3)

1929

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ACKNOWLEDGMENTS

The writer is indebted to Professor Wolfgang Köhler of the Psychological Institute of the University of Berlin, for giving him every privilege and the equipment necessary for the present study, to Tamara Dembo, also of the University of Berlin, for her valuable assistance in many of the experiments, and especially

to Professor John F. Shepard of the University of Michigan, who was in touch with much of the work while in progress and who critically read the manuscript, for his kindly understanding, valuable criticism, and suggestions.

I. HISTORICAL

Since Koehler's work with chimpanzees (6) the doctrine of "trial and error" has been considerably questioned even in the case of rats. Although insight has not been directly proved in their case, some experimenters have hinted that they are capable of it.

Higginson (5) points out that there is a sudden readjustment to significant environmental changes. He taught his rats to go 6 feet past a closed door, in a circular maze, to the end of a "blind" and then to return and find the door open. After 100 repetitions the door was left open in the beginning. Five of the nine rats which he used, noted the change and took the open door without going to the end of the "blind" as usual, and from this point continued the run without error. This, he believes, was a visual adjustment to the changed environment. Although it was Higginson's purpose to demonstrate visual perception, it should be pointed out that he did not prove a visual adjustment. The rats may have reacted to a change made in the maze, but what he calls adjustment may have been curiosity. Tolman (12) commenting on the same point says that there is a general tendency for a rat to take any new pathway. Hence it can only be said that the rats reacted to a change in the situation. Nor can one be sure of the cue to which the animals reacted. It may have been auditory rather than visual.

Because the rats continued the maze correctly from this point on, shows only that they got sufficient cues at this point.

Helson (2) shows that rats respond to visual structures and not to elements. Thus animals trained to go to a certain light B instead of a less bright light A, go to light C instead of B, when C is brighter than B. The rat chooses the relatively brighter light rather than the absolute brightness with which the food has always been received. The relation brighter involves the whole

structure and the association is made with the whole "bi-membral structure" rather than with an element in the situation. Koehler (7) has shown this to be the case in apes and chicks, and Moody (9) in the case of mice. This response to structure rather than to an element in the structure can hardly be considered proof of insight as Helson contends (p. 389). In the case of 2 of the 4 rats used, Helson believes he has a second criterion for insight. In order to reach the food the rats had to climb over a platform on which an electric shock was given in case the rat went wrongly. As the rats did not learn, in this case, which way to choose for the food and the avoidance of the shock, they soon developed a negative association with the platforms of both compartments. To avoid the shock and still obtain the food, two rats now scaled the wall between the compartments and so reached the food. This may be an expression of insight as Helson contends, yet not necessarily so. As the food had a positive association and the platform a negative association, the response might have been the resultant of the two stimuli. An insect positively phototropic will crawl directly toward the light. If some of the legs are removed on one side of the body an adjustment is made which is not called insight. Or an ant on its way to food will successfully go around a disagreeable substance, placed in its path, without being credited with insight.

Thorndike found that cats solve "puzzle-box" problems by "trial and error" and from this he generalized that animals are only capable of this type of solution. Helson points out that this generalization is incomplete, because it does not necessarily follow that animals are only capable of this type of solution because "trial and error" is used to solve the "puzzle-box." This criticism may be valid, but Helson's experiments do not substantiate its validity.

Koehler (6) has probably demonstrated insight or intelligent solutions in the case of apes. His method of "round-about-ways" to food presents the animal with problems in which there is a chance for intelligent solutions. The animal is allowed to become familiar with the whole situation and thus is able to apply its knowledge of that situation to the problem in an intelligent

manner. Two considerations, however, raise some doubt; (1) the past experience of the animal was not controlled and (2) the question as to whether the solution was "clear-cut" or not was the important factor in the conclusions and depended on the interpretation of the experimenter rather than on objective measurements.

Miss Hertz (3) working with 3 crows made some interesting observations which, however, did not deal with insight and so do not concern us here. In a second paper (4), using 1 crow, she reports experiments similar to some of Koehler's on the apes and with apparently positive results. Through holes in the cage she taught the bird to pass nuts which she then cracked for it. The bird had to respond not to a single stimulus, but to a whole situation-structure (nut—observer—hole) in order to reach the goal (nut—meat). The bird showed 3 tendencies (1) to hide the nut, (2) to go toward the observer, and (3) to pass the nut through the habitual hole. By varying her position she could see whether these 3 tendencies were integrated in a sensible manner.

Using 2 holes, the bird with the aid of coaxing, chose the hole before which the observer stood. On the third day this was done without the aid of coaxing (calling the bird toward her). Using now a third hole on the sixth day coaxing was again required. The following day no coaxing was required. On the tenth day she stood before a fourth hole and the bird passed the nut to her without coaxing.

Thus the bird learned to use the different holes so that on the tenth day the relation "hole nearest the observer" was responded to, rather than a particular hole. This responding to the relation was learned and need not be any different from the responding to the brighter of two lights.

She then did some "similarity experiments." Nuts painted in different shades of gray were still recognized. Small nuts covered with gypsum were also used. She concludes that the bird recognizes not only the walnut as it appears naturally, but also disfigured nuts, the more disfigured the less easily recognized. Thus the bird has different stages of recognition and can do more

than make mere positive or negative responses. As she has not analyzed all of the cues one cannot state which complexes of cues call up a response toward the nut and which complexes do not.

In her "relation experiments" she finds that the bird chooses a hole that is large enough for the nut. As the bird has learned to respond to the whole nearest the observer and as it does not respond when she stands anywhere before the cage, a small hole does not call out the response of passing the nut through. This shows that the animal has good vision and is responding to the relation "size of nut to size of hole."

She states that the structure which gives the situation a definite sense for the bird is "nut inside, observer outside." Such a conclusion as to what is sense for a bird is an interpretation which is not forced by the facts.

The "obstacle experiments" approach those of Koehler. Three stones were placed before a door the middle one of which blocked a door which the bird had learned to open for food. In the experiment the bird walked back and forth before the door, the stones being in its path. The middle stone was then attacked, it resisted, the other two were then moved and only later the middle stone. One wonders whether the stones were attacked because they were in the way and the bird stumbled over them.

On repeating the next day all stones were again moved. She says, "Der Versuch ist ungünstig beeinflusst dadurch, dass das Ziel nicht recht 'zieht.'" Again an uncalled for interpretation.

Only on the fifth day is the correct stone removed first, but this time the two end stones were 70 cm. from the middle stone and so out of the situation.

Using a small and a large lever as latches which serve as obstacles for the door, she gets somewhat more significant results. The latches are moved by the bird, sometimes enough and sometimes not enough. The latter she excuses by saying that the latch was moved almost enough and that the bird could not make out so small a difference in the complex. Yet we know that the bird's eyes are very accurate from her relation experiments.

As the latch is a new element in the situation and as the door

resists, it does not require an understanding of the situation for the bird to attack the new element. If clear-cut results are gotten after a few repetitions we do not know how much has been learned. The fact that a later experiment in which the stone was again the obstacle and the latches placed so as not to block, resulted in the bird's attacking the stone instead of the latch, does not prove understanding because the stone had been attacked in previous experiments and was now the most obvious object. Would the bird attack a lone stone lying near the door, but not being an obstacle? With the stones and latch both serving as obstacles she got a solution which was not clear-cut, but was followed by a clear-cut one. She excuses the first by saying that the tendencies were not organized.

Thus with one bird as a subject, with solutions that are not clear-cut, and with an observer that is decidedly prejudiced one can only express grave doubts as to whether birds have an understanding of problems, and whether there are such things as sense and non-sense situations for it.

Multiple choice, delayed reactions, and sudden drops in the learning curve all may have a close relation to intelligence. They do not, however, give us clear-cut cases of insight. Yerkes' (13) orang-utan did so poorly in the multiple choice test that he believed it used "wrong ideas." Mastering the multiple choice problem involves many trials so that an original solution is never obtained. Delayed reactions involve more the problem of memory images (or some factor of substitutive value) and although memory images may be of great value in solving problems, insight or reasoning is not demonstrated if they are shown to be present. The sudden drop in the learning curve may be evidence of insight or abstraction; however, attention, anatomical differences in vision, etc., are such important factors that one can hardly consider such a drop as valid evidence in favor of insight.

As far as published evidence goes there is then little or no evidence that animals, except man and perhaps apes, have insight. The laws of association seem quite adequate to explain animal behavior, at least at the level of the rat, if not of the ape. The rat's great capacity for learning has, however, caused con-

siderable trouble in the application of these laws. Shepard (10) in studying the rat's learning of very complicated mazes and finding marked ability in their adapting to changes, has come to the conclusion that the mind of the rat is not nearly so simple as is usually supposed by the animal psychologist.

II. STATEMENT OF PROBLEM

The purpose of this investigation is to learn whether or not rats can solve problems without "trial and error." That is, can a rat, placed in a certain situation, adjust itself intelligently or adequately for its purpose, without previously having learned to respond in the situation concerned and without making a series of random responses that finally lead to an adjustment. Or further, can a rat be placed in a situation in which it can, by its solution, demonstrate insight?¹ Is the "puzzle-box" a valid measure of animal intelligence? Does it fully test an animal's capacity or can a rat behave in a manner that might be called reasoning? If it can reason, then (1) it must adequately adjust itself to a new situation, (2) it must be able to apply essential relations from other experiences to the new situation, and (3) the solution must be a continuous whole directed toward a definite end. This end need not be consciously appreciated.

III. METHOD AND RESULTS

The experiments were begun at the Psychological Institute of the University of Berlin in the winter of 1926 and were continued at the University of Michigan in the Fall of 1927. Three rats, A, B, and C, were used in Germany. At Michigan seven were available part of the time, but in most cases only six were used. They are nos. 44, 46, 47, 48, 49, 50, and 51. All but 51 were experienced rats which had been used in maze work the year before. All of the ten rats were males, at least 7 months old.

The "set-ups" used vary from experiment to experiment and

¹ Insight is here used as Koehler uses it when describing it objectively, a connected or continuous or whole response which appears as a whole and may come suddenly, or may manifest itself as a sudden change in activity.

will be described in each case. Rats A, B, and C were put through a large number of "set-ups" and in some cases only enough results will be given to indicate training and qualitative results. The quantitative results were obtained largely with the rats used in the University of Michigan laboratory.

The problem for the rat was to obtain food which was so placed that it could not be reached directly. The normal or obvious route to food was blocked by a cage shaped like a triangle, one side being open, the other two sides and the top being made of wire. This cage was clamped to the table so that the open side extended about 15 cm. over the edge of the table. The pathways leading to food (that is, the indirect route) were made of strips of wood 2 cm. by 2 cm. in cross-section and were supported on tables and ringstands. Thus some of the pathways resemble the mazes described by Miles (8). The units of these pathways are designated by numbers in the figures.

The starting point in the test was always on one side of the cage and the food on the other. The rats having been trained positively to a light, an electric light wrapped in paper was placed beside the food (unless otherwise indicated) and served as a food stimulus in case olfaction was not sufficient.

A general description of the situation is as follows: Point A is the starting position and F is the position of the food. F is separated from A by the wire cage. Let b, c, d, and e be points on the maze which leads from the table to food, and let g, h, i, j, and k be any points on the table except b. If the rat has previously been permitted to become familiar with all points except those lying on the maze (which has not been constructed at this time) then point b is no more favored than the points g, h, i, j, and k. After the situation has become familiar, the pathway is set up and the rat is taught to go from b to F. In the test the rat is placed at A, so that the only way to food is A-b-F. In order to reach the food the gap A-b must be filled in. The rat can do so, either by using the experience gained previously to learning b-F (i.e., selecting the relation A-b rather than A-g, a-h, or some other) or it can wander away from A until by chance it comes to b which sets off the chain of associations that lead to F.

The first type of solution would be an "intelligent" solution, the second a "trial and error" solution. The rat does finally reach the food, it remains, therefore, for the results to show which of these solutions it uses.

The first type of solution, if described from behavior only, would show the animal trying to reach the food directly with considerable activity at point A, and then a direct and active running to point b and without hesitation continuing along the pathway. The second type would also show the rat trying to reach the food directly and then a gradual increase in activity at point A. This heightened activity would take the rat farther and farther from A until it carried the rat to far points on the table including point b. At b there would be sign of recognition (halting) followed by a taking of the path.

Rats not familiar with, or having no knowledge of the pathway b-F, should come upon b (although they might not take the pathway) just as soon as the rats which know the path, if the latter did not apply their previous experience, but came upon it by random wandering around. If, however, they applied their experience of the table (points b, g, h, i, j, and k) to the situation, then there should be a considerable difference in time in going from A to b, for rats with and without the experience of running b-F. The same difference should hold also for rats familiar and not familiar with the immediate surroundings (points b, g, h, i, j, and k).

In the descriptions of the individual experiments given below, those done in Germany will be listed under the letters of the alphabet and those done at the Univ. of Mich. will be numbered. The order will be logical rather than chronological, but in order that the reader may know the training of the rat, the chronological order will be given in parenthesis.

When qualitative results are given, the points covered by the rat will be given in letters and numerals (separated by a dash) which can be located in the figures that accompany. If letters or numerals are omitted, leaving gaps, it means that the rat took the most direct route between the points indicated. The time in seconds is given in parenthesis, showing when the rat reached certain points.

All the rats were well tamed and their fear of running along the narrow strips eliminated by learning a practice maze.

In giving results, certain phrases are used which might suggest an anthropomorphic interpretation. This is not implied in any case. When it is said that a rat "looked for" a certain pathway, only the characteristic behavior accompanying seeking is implied. If a rat repeatedly returns to and thoroughly explores a certain region from which a pathway previously led, the phrase "looking for" the pathway is used. Or if it is said that the rat "had a knowledge of" a certain room, it is meant that the rat was able to find its way successfully about that room. Thus if a rat has learned a maze it can be said that it has a knowledge of the maze without implying any conscious equivalent.

Experiment A (1)

Fig. 1 gives the "set-up" used in this experiment. Tx and Ty are halves of the large table which is divided into two parts by means of a pasteboard wall (r p) 40 cm. high. The dotted lines indicate the wire cage. The pathway on the maze is given by numbers, the odd numbers indicating the true path, the even the blind alleys. Letter b is the starting point of the maze and lies within the box² at the corner of the table. It has two openings toward the side of the table and can only be entered with difficulty. The broken lines indicate parts of the pathway which were added later and were present only when referred to.

A couple of weeks before the experiment the rats were placed on the table and permitted to become thoroughly familiar with it, and had learned to scale the pasteboard wall. The maze was then constructed and the rats were allowed to learn the way from the inside of the box (b) to F. The rats had never entered the box on their own initiative.

In the test the rat was placed at A and the food remained at F.

² This box was 25 cm. high and was placed evenly with the edges of the table. It was closed on all sides except for 2 small openings or doors (10 cm. square) about 10 cm. from the ends of the box. The pathway began at one of these openings.

Results:

Rat A. 1. A—Around sides of cage—back and forth on table near the cage—at p (50)—A—tries to get around cage (80)—15—over wall at p (100)—directly to box—at b (125)—F (147).

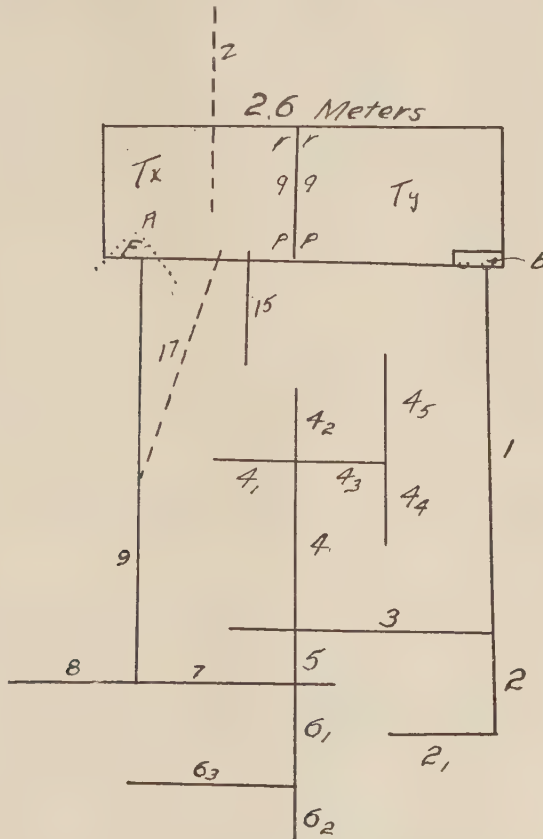


FIG. 1

2. A—tries to get around cage—15—over wall at p (12)—b (18)
—F (30).

Rat B. 1. A—tries to get around sides of cage—q (25)—A—q (60)
—A—15—over wall at p (85)—b (105)—F (120).

2. A—around cage—over wall at p (17)—b (22)—F (32).

Rat C. 1. A—active near cage—back and forth on table—15 (70)—over wall at p (75)—b (85)—F (105).

2. A—around cage—over wall at p (34)—b (38)—F (55).

Thus in every case there was a marked tendency to go directly to the food. After, however, the rats got as far as scaling the wall (which was quite a feat and was only done after more than a week's familiarity with the table) they went almost directly to b. In the first test run this scaling of the wall was done with some hesitation, time was also lost in getting inside the box to reach b (b could only be reached by the rat's crawling over the top of the box, or by means of one of the openings which put the rat in danger of falling), and there was also a tendency to sniff at objects lying on the table which were placed there to give added character to the table.

The time between scaling the wall and reaching point b is the best indication of the directness of the run. The average time for the three rats was 18.3 seconds for the first run and 5 seconds for the second.

Certain variations were made in the third and fourth runs of this experiment. In one of the runs path 17 was put in and in the other path Z.

In every case each rat took 17 or Z, depending on which was there, instead of going as it had in the other two runs. This same tendency to take any new path was also shown on other occasions. A path well learned will be neglected in order to explore a new path no matter at what angle the new path leads from the old. One of the films made in Germany also shows this tendency very clearly. A path was well learned and then long and short-cuts were introduced from time to time. At first the new path was always taken at the first opportunity, but after the third and fourth change the new path was not always taken on the first opportunity.

Experiment B (2)

To study further the behavior of rats in solving this type of problem we varied the experience of each rat. One rat learned

the part b-F as usual, one learned it after the first run, and one did not learn it at all. In order to exclude influences from the preceding experiment, a different room and different apparatus were used. In figure 2, T, M, N, and O are tables; and m, n, o, and p, are paths leading from the center of T. A, F, and b have their usual designations, and x, y, and z are positions on T.

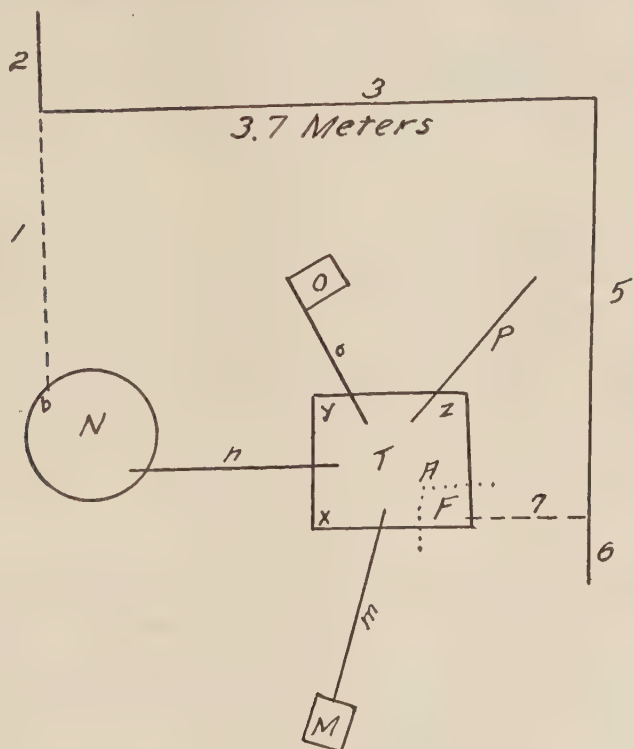


FIG. 2

All three rats were placed on T a couple of hours before the experiment, so as to become familiar with the tables. The cage, and paths 1 and 7 (represented by broken lines in the figure) were, however, lacking. Thus the rats were unable to explore the maze part of the round-about way. Before the test the rats were removed and the cage and paths 1 and 7 put in place.

In the learning of b-F, the rat was placed at b and made to go along the path. After the first trial it was placed in the center of N, but not allowed to go near n. Three learning trials were given.

Results:

Rat A. Learned b-F. Tested 10 min. later.

1. A—tries to get around cage—m (25)—M—A (30)—top of cage—crawls on sides of cage—p (75)—o—O (90)—n—N (100)—directly to b without hesitation—F (115).

Half hour later.

2. A—mh³ (5)—n (6)—N—b—F (23).

Rat C; b-F not learned.

1. A—top of cage (15)—ph (30)—A—top of cage (50)—tries to get around cage—runs about center of T—A—top of cage (135)—bites wire of cage (150)—top of cage (165)—mh (175)—m—M (183)—remains sitting at M—taken up (300).

10 min. later placed at F and allowed a bite to eat.

2. A—top of cage—A—mh (55)—A—bites wire of cage (85)—mh (95)—n (135)—N—2—F (165).

3. A—m—M (10)—n (13)—N—2—F (40).

4. A—n—N—F (25).

Rat B; b-F not learned.

1. A—around cage—ph (45)—A—top of cage (60)—A—top of cage (85)—A—m (103)—M—A—top of cage—bites wire (150)—tries to get around cage (165)—top of cage—oh (210)—nh—m—M (240)—sits at M 40 sec.—A—top of cage—A—not active, taken up (300).

10 min. later, b-F is learned as in the case of rat A.

After another 10 min. interval it is tested.

2. A—runs about sides of cage—p half way (15)—A—ph (30)—m—M (40)—A (45)—top of cage (55)—ph (30)—m—M (40)—A (45)—top of cage (55)—ph (60)—o (70)—O—n (80)—N—b—F (95).

3. A—ph (5)—n (15)—N—2b—F (35).

The behavior can be somewhat statistically handled if we compare the rats on the following points:

³ "h" = hesitation at the path indicated by the preceding character.

1. The time the rat spends at the cage before moving any distance from it. 1a. Time before leaving cage. 1b. Time before leaving table. This indicates whether or not there is a tendency to seek a round-about-way. If the time is long it may indicate giving up. (As all paths leading from the table have previously been explored they offer no attraction.)

2. Hesitations before different paths leading from the table. This indicates knowledge of the previous explorations. If, however, later experience has shown that a path starting from one of the tables leads to food, then the tendency to hesitate at paths leading to tables, might be removed.

TABLE 1

RAT	LEARNING	1a	1b	2	3	4	5
First run of each rat							
A	b-F learned	seconds 25	seconds 25	0	4	3	98 seconds
B	b-F not learned	45	103	3	2	0	Taken up 300 seconds
C	b-F not learned	30	180	3	1	0	Taken up 300 seconds
Second run of rats B and C							
B	b-F learned	15	15	1	4	2	80 seconds
C	b-F not learned	55	135	1	1	0	135 seconds

3. The number of times that the rat leaves T. If this number is large it may indicate active seeking, if small and after long waits, giving up.

4. The number of paths taken in succession. If paths are taken successively it probably indicates seeking. Normally the rat returns to the starting point (cage).

5. The time elapsing before n (which leads to b) is taken. The rats seeking b should reach n before those which come upon n by chance.

In table 1 the rats are compared on the basis of these points.

This table clearly brings out differences in the behavior of rats that have and have not learned b-F, and striking likenesses be-

tween those that have the same previous training. (Compare the 1st run of rat A with the 2nd run of rat B.)

Experiment C (11)

In Experiment B it was stated that rats hesitated before paths leading from the table, when b-F was not known, because all paths leading from the table had been visited before and had been found to have blind ends. If this statement were true, then rats unfamiliar with the table and paths leading from it as well as path b-F, ought to have an advantage over those familiar with the territory; but unfamiliar with b-F.

To test this, a set-up which in principle was the same as in experiment B was used. There were three paths leading from the table on which the rats were started.

TABLE 2

RAT	TRAINING	HESITATIONS	PATHS TAKEN IN SUCCESSION	TIME BEFORE REACHING b
				<i>seconds</i>
A	Table only	5	0	176
B	Table and b-F	1	3	30
C	Nothing	0	3	30

The training of the rats was as follows: Rat B was familiar with the table and b-F; rat A was familiar with the table but not b-F; and rat C was unfamiliar with the whole situation.

From table 2 we can see a marked similarity between the behavior of rats B and C, the first having complete training, the second, no training at all. In regard to the behavior of rat A, it must be remembered that the rats are now accustomed to taking round-about paths to food (this being the 11th experiment) so we can expect rat A to be seeking a way to food even if it does not know where the pathway begins.

Experiment 1 (1)

In a series of 7 "set-ups," of which fig. 3 is typical, the rats were divided into two groups of three rats each. The groups were alternated, one learning, the other not learning b-F. As

usual all rats were familiar with the territory, and later b-F was set up.

Only the time the rat uses in getting from A to b is a valid comparison (as running from b to F has been learned by one group and should be more rapid), so A to b is the only time given. For the rats that did not learn b-F, any wandering within 50 or 60 cm. of b was considered as arriving at b, (it being assumed that if b-F had been learned it would have been taken). In letting the rats learn b-F they were not allowed to investigate more than 40 or 50 cm. from b, (designated as g in fig. 3).

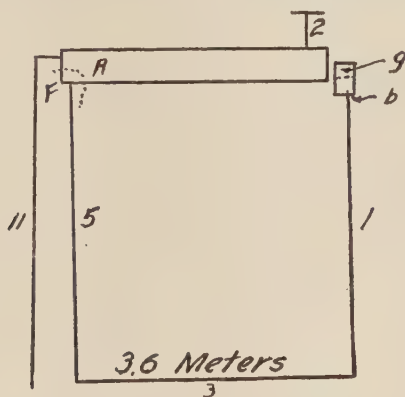


FIG. 3

The number of rats making errors and the total number of errors made by each group are also given. (An error is the visiting of paths or tables not on the main platform.) As g is an extension, so other extensions were added from time to time, making the possibility of errors greater in some experiments than in others.

Path 11 had been present when the rats were learning to become familiar with the wooden strips, and had led to food. In "set-up" (a) of this experiment it was taken by all of the rats. This was their first experience with such a problem.

Table 3 gives the average time in seconds for each group of 3 rats, for the first and second run of each of the seven "set-ups," as well as the errors.

This table brings out the marked advantage that the rats have when they had the experience of learning b-F, both in time and the avoidance of errors. It may be added that in every set-up, except for 1a, the time for the slowest rat that learned b-F was less than the time for the fastest rat which did not learn b-F.

The time for going from A to b is unusually large in "set-ups" 1a and 1f. This is due to carry over tendencies from preceding days when path 11 led to food. As the time used for sniffing at the food behind the cage is included in the table, an average of 48.6 seconds is really low and includes many perfect runs.

TABLE 3
Time and errors for second run in parenthesis

SET-UP	b-F LEARNED			b-F NOT LEARNED		
	Average time A-b	Errors		Average time A-b	Errors	
		Number	Cases		Number	Cases
1a	145 (22)	3 (0)	3 (0)	180 (23)	6 (2)	3 (2)
1b	32 (9)	0 (0)	0 (0)	416 (14)	9 (0)	3 (0)
1c	18 (12)	1 (0)	1 (0)	65 (9)	6 (1)	3 (1)
1d	16 (11)	1 (0)	1 (0)	80 (9)	2 (0)	2 (0)
1e	37 (12)	2 (0)	2 (0)	183 (17)	12 (0)	3 (0)
1f	85 (16)	6 (0)	2 (0)	470 (14)	33 (0)	3 (0)
1g	8 (8)	1 (0)	1 (0)	57 (11)	7 (0)	3 (0)
Average ...	48.6 (13)	2 (0)	1.4 (0)	207.3 (14)	10.7 (0.4)	2.9 (0.4)

Experiment D (12)

In order to reduce the possibility of chance solutions the "set-up" shown in Fig. 4 was used. This experiment was done on the same day as experiment C and part of the arrangement is the same. The arrangement of W was exactly the same except that one of the paths leading from it was removed in this experiment. The correct path had been from n to Ty to Tx, which was now a blind. The path leading to food (b-F) begins in the adjoining room. In order to reach the food from A the rat must descend the ringstand RS, go into the next room, climb on top of the nest-box c, (which sets on a chair) jump across to d, and run 1-3-5-F. The observer stands at E.

The rats, of course, are thoroughly familiar with both rooms, as they were usually released from their nest during the day. They have often been on top of their nest-box (c) and had jumped to table d, when the gap was 50 cm., in order to find food. A month before this experiment the gap was made too large for them to jump, and after several failures they gave up trying. For this experiment the gap was made 40 cm.

As this is the 12th experiment and was done about two months after Experiment B we must recognize considerable development. They have performed experiments (which will be given

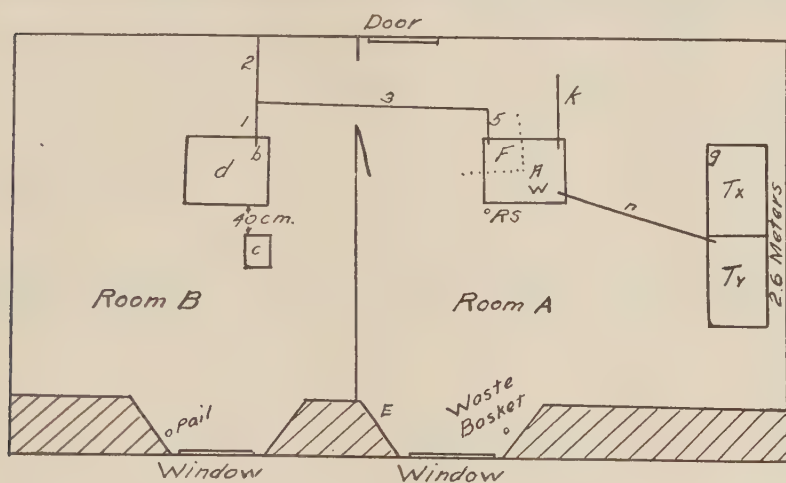


FIG. 4

later) in which they learned to use the floor as part of the path, and have learned to go up and down ringstands for this purpose. For this reason none of the pathways were supported by ringstands, but instead were fastened to the walls. (With the presence of ringstands a chance solution could soon have been found.) Paste-board wings were also added to the sides of the cage, as the rats did not hesitate to perform difficult feats to get the food.

Rats B and C were taught part of the solution (b-F), the part taught will, however, be given in the record of the runs, and rat C was taught nothing, but was placed at F for a bite, to control any extra incentive that might be gained from having eaten.

Results:

Rat B. Learned d-F. 3 repetitions.

1. A—n—Ty (12)—Tx—g (where path left in Exp. C)—A (50)—RSh—kh—n—Ty (60)—Tx—g—A (90)—down RS (95)—sits in doorway—middle of room A—RSh (130)—around room A—*taken up*⁴ (140).

2. A—n—Ty—Tx—W—RSh (60)—A (62)—nh (68)—k—A (80)—down RS (90)—around room A—*taken up* (140).

d-F shown once more.

3. A—n—Ty (8)—Tx—g—A (38)—down RS (45)—*taken up* (80).

The rat is now shown the way c-d-F. 3 repetitions. (Without hesitation it jumped from c to d.)

4. A (washes)—n—Ty (13) (washes)—A (30)—RSh (45)—n (53)—Ty—Tx—g—A (110)—kh—A (115) (washes)—RSh (140)—RS down (145)—doorway (175)—room A (205)—*taken up* (210).

c-d-F shown again.

5. A—kh—A (15)—RSh (22)—n (27)—Ty—A (58) RSh (80)—A—down RS (100)—doorway, sits (140)—direct to chair on which c rests (160)—to c (165)—d (170)—F (181).

In the next two runs the rat still hesitated before RS and tried going to Ty first. When RS was taken the rat went direct, except that in each case there was a slight halt before entering room B. The 8th run was perfect.

Rat C. d-F not learned. Placed at F to eat a bite.

1. A—n—Ty—Tx—A (40)—RS down (50)—around room A—doorway (75)—room A—*taken up* (90).

2. A—RSh—n—Ty—Tx (15)—A (30)—down RS (43)—crawls up E's leg (60)—*taken up*.

3. A—n—Tx (10)—A—down RS (20)—wanders about room A and remains sitting by window.—*taken up* (60).

4. A—down RS (10)—room B (20)—sits in the pail in corner of room B (See fig. 4) where the rats often are to be found during the day.—*taken up* (60).

Placed at F and given bite of food.

5. A—Ty (10)—Tx—A (45)—RSh—down RS (58)—up E's leg—*taken up* (100).

6. A—Ty—Tx—A (30)—down RS (37)—room B (60)—*taken up* (100).

⁴ The rat was taken up only when it showed very little activity and had apparently given up. Comparing the time for two rats' solutions is only valid when the time consists of active seeking.

7. A—RSh—Ty (18)—Tx—W—k (35)—A (45)—top of cage (60)—down RS (95)—*taken up* (140).

8. A—top of cage (10)—Ty (22)—Tx—A (33)—down RS (44)—up E's leg—*taken up* (80).

It learns c—d—F. Two repetitions for d—F and 4 for c—d—F.

1. A—n—Ty—A (20)—RSh—A (25)—n—Tx—A (45)—top of cage (55)—A (67)—down RS (75)—very active about room A—RSh (120)—*taken up* tho still active (130).

Two more repetitions of c—d—F.

2. A—n (10)—Ty—A (35)—down RS (40)—*taken up* (60).

One repetition of c—d—F.

3. A—down RS (7)—room B (30)—by window—*taken up* (60).

One repetition of c—d—F.

4. A—n (8)—Ty—A (42)—down RS (48)—direct to other room (58)—direct to chair—on top of c—d (70)—F (78).

In the next run Ty was also visited. The 6th run was, however, perfect.

Rat A. No learning of path c—d—F.

1. A—n—Ty (12)—Tx—g—A (53)—RSh (58)—A—RSh (70)—A—kh—n (90)—Ty—Tx—A (105)—kh—l (115)—down RS (125)—active in room A—up RS—A (195)—Ty—Tx—A (240)—top of wire cage (255)—A (270)—down RS (280)—around room A—RSh (315)—up RS—A (335)—bites on wire of cage—k (375)—n—Ty (385)—Tx—A (420)—RSh—A—top of wire cage—fell to floor trying to get around cage (440)—in room B (455)—sits in pail—*taken up* (515).

Placed at F and given bite to eat.

2. A—n half way—A (15)—down RS (45)—around room A—up RS (60)—A (65)—top of cage—tries to get under cage—kh (115)—n—Tx (120)—A (150)—top of cage—finally gets around cage and reaches food (210).

From this point on, the rat was prevented from going around the edge of the cage. It did not resent this interference and seemed to try and do it on the sly. Sometimes just walking towards it would cause it to get off the cage.

3. A—n (10) A—top of cage—forced down—A—down RS (58)—around room A—*taken up* (110).

4. A—sniffs about cage RSh—A—washes (25)—alternately sniffing at food and washing—n (130)—Ty—Tx—A (190)—A—bites at wire (210)—washes—down RS (295)—room B (320)—sits by pail (360)—*taken up* (390).

Placed at F and given bite to eat.

5. A—n—Ty—A (40)—sniffs at food—bites wire (58)—RSh (75)—A—top of cage—forced down—A (85)—RS down (125)—around room—*taken up* (150).

6. A—nh—A—RSh—A (23)—n—Tx—A (70)—down RS (75)—room B—sits in pail—*taken up* (110).

Placed at F for bite of food.

7. A—washes—down RS (30)—room B (40)—in pail—*taken up* (70).

Thus rat A had 7 trials (and if we counted the long runs in which it returned to the starting point, there would be 10 trials) in which it used 25 minutes and 55 seconds but without succeeding in finding the food.

Rat B reached the food on the fifth trial after 12 minutes and 31 seconds. Had it been shown the way c-d-F instead of d-F in the beginning rather than after the 3rd trial, its record probably would have been still better.

Rat C after 8 trials had not succeeded in hitting upon F. After this number of trials it no longer showed signs of trying to get to the food. To continue would have only added trials which were meaningless. In these 8 trials $11\frac{1}{2}$ minutes were used, as against $9\frac{1}{2}$ minutes used in the 4 unsuccessful trials of rat B. After rat C was taught c-d-F, it reached the food in the 4th trial or in a total time of 5 minutes and 28 seconds. This time is less than half the time used by rat B, after part of the path was learned. Rat C, however, had the advantage of learning c-d-F from the start, and in addition it had the 8 earlier trials to learn at least some of the things not to do. Thus going to Ty was more easily dropped.

Experiment E (13)

In a series of 4 "set-ups" each rat was shown a different pathway to food (i.e., b-F was different for each rat). The starting points (b) of these pathways were in different parts of a known room. Thus from A there were three possible round-about routes to F. If these paths were discovered by "trial and error," then the chances were 2 to 1 in favor of getting one of the paths that had not been shown.

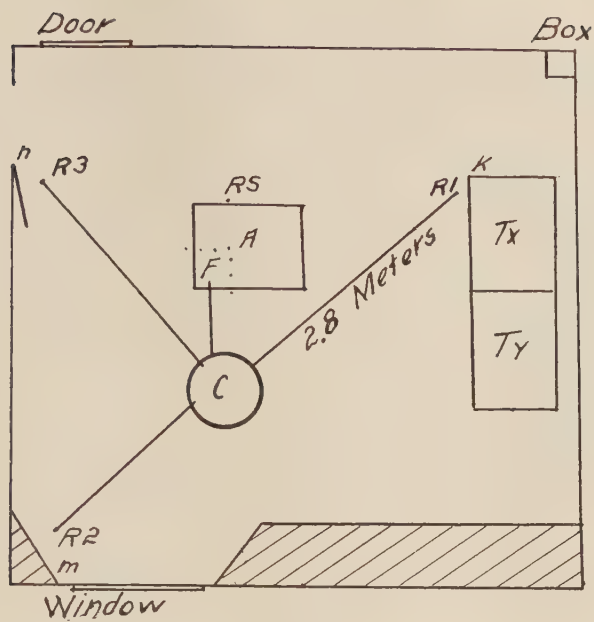


FIG. 5A

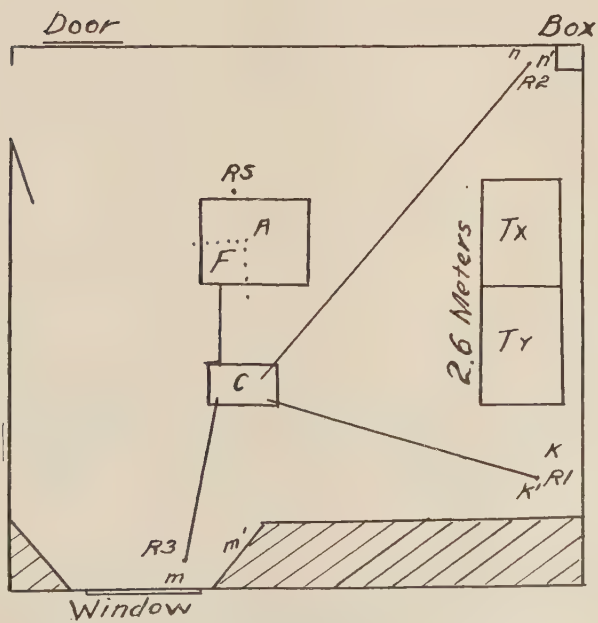


FIG. 5B

Figures 5a, 5b, 5c, and 5d show the "set-ups" that were used. In these diagrams, b is the base of the ringstands which are

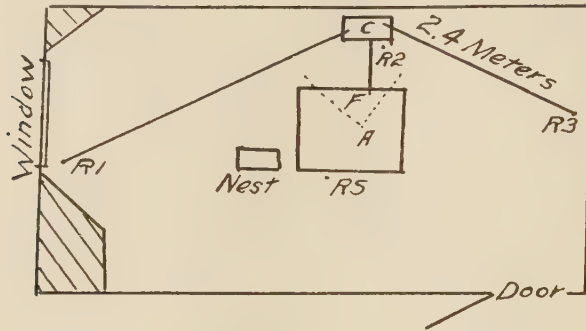


FIG. 5c

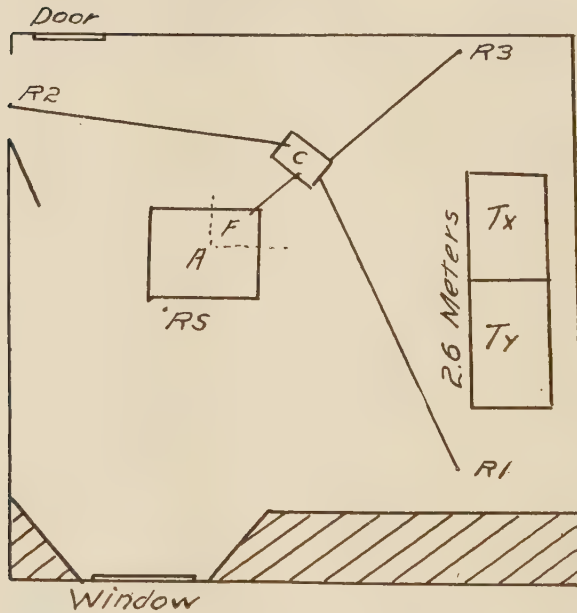


FIG. 5d

designated by R1, R2, and R3, A path with the corresponding number leads from the top of the ringstand to table C. From C a common path leads to F. The letters k, m, and n are posi-

tions near the bases of the ringstands where the rat was placed (in the learning series) so as to go up the ringstand. This gave the rat a chance to locate the ringstand with reference to the room. (As these points were always farther from the center of the room than the ringstand itself, the unlearned portion of the round-about path was in no way partly bridged.) RS is the ringstand leading from table A to the floor.

To reach the food when placed at A, the rat must descend RS and find either R1, R2, or R3. If the path from one of these points has previously been learned, the rat will go to that ringstand, providing such learning played a part in its behavior.

The following is a typical example of a rat's behavior in this experiment, and the way it was shown part of the way to food. (In the learning of this part way, the rat was only allowed to take the pathway leading to F after arriving at C.)

Results:

Rat A. Set-up 5a.

Learning series. (1) C—F, (2) 1—C—F, (3) R1—1—C—F, (4) k—R1—1—C—F.

Test. 1. A—around table and cage—down RS (45)—floor (52)—under Tx (62)—up R1 (64)—F (75).

2. A—RSh—A—RSh—down RS (27)—floor (30)—up R1 (35)—F (45).

Set-up 5b.

Learning. (1) R1—F, (2) m—R1—F, (3) m'—R1—F.

Test. 1. A—RSh—A—down RS (39)—floor (41)—R1 (50)—F (57).

2. A—down RS (12)—up R1 (22)—F (29).

The remainder of the results will be given in tabular form. Only the time spent on the floor, and perhaps the time before going to the floor are of importance. These will be given as well as the pathway that was taken in each case. See table 4.

Rat A always learned from R1, rat B from R2, and rat C from R3. The position of these ringstands was always radically changed for each "set-up" so that if there was any carry over effect from the previous day's run it was a handicap rather than an asset. During the day the "set-up" was not present and the rat was given the freedom of the room.

In every case each rat took the path it had been shown, and in a very direct manner as the time on the floor shows. The time on the floor for the second run is a good measure of the minimum time in which the distance could be covered when the rat is most active.

After each of these experiments the rats were placed at some point on the floor which was about equally distant from the three ringstands. In every case the rats reached the food by way of

TABLE 4
Second run in parenthesis

SET-UP	RAT	TIME BEFORE ON FLOOR	TIME ON FLOOR	PATH TAKEN
		<i>seconds</i>	<i>seconds</i>	
5a	A	52 (27)	12 (5)	1 (1)
	B	75 (15)	30 (15)	2 (2)
	C	70 (12)	30 (8)	3 (3)
5b	A	39 (12)	9 (10)	1 (1)
	B	24 (4)	3 (4)	2 (2)
	C	20 (11)	9 (7)	3 (3)
5c	A	68 (12)	6 (8)	1 (1)
	B	39 (17)	2 (2)	2 (2)
	C	40 (14)	6 (4)	3 (3)
5d	A	50 (7)	11 (8)	1 (1)
	B	49 (17)	6 (7)	2 (2)
	C	32 (10)	18 (5)	3 (3)
Average.....		46.5 (13)	12 (6.9)	100% correct

the pathways they had been taught, but in 5 of the 12 cases the rats first went up RS to A and from there went to the correct pathway. In the next run these rats went directly to the pathway without first going to A. Thus in "set-up" 5a, rat B went to A on the first trial and from there to the pathway, while rats A and C went directly to the correct pathway. In none of the 12 cases was the wrong pathway taken and in every case the rat went in very nearly a straight line to the ringstand.

Experiment F (13)

This experiment is like the preceding one, except that strange rooms were used instead of familiar ones. The experiments were actually alternated, first one in the known room, then one in the strange room, etc. The procedure in both experiments is the same except that in the strange rooms a slightly larger area

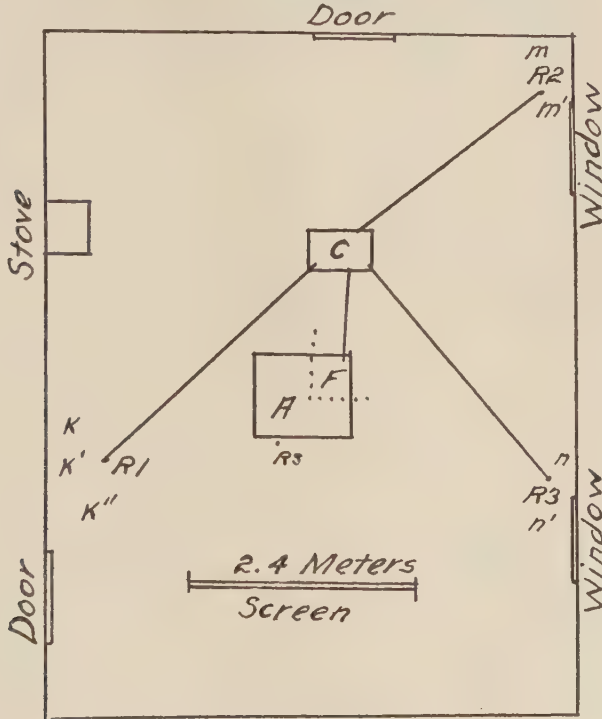


FIG. 6A

on the floor near the ringstand was learned in the training series. (The rats were allowed to go to the ringstand from two or three points, which were also somewhat farther away from the base of the ringstand than in Experiment E.)

The "set-ups" are shown in figures 6a, 6b, and 6c. The set-up in 6a, is identical with 5a, except for the room.

A few typical runs are given in detail.

Rat A. "Set-up" 6a.

Training. Learns (1) c—F, (2) 1—c—F, (3) R1—c—F (4) k—R1—c—F, (5) k'—R1—c—F, (6) k''—R1—C—F.

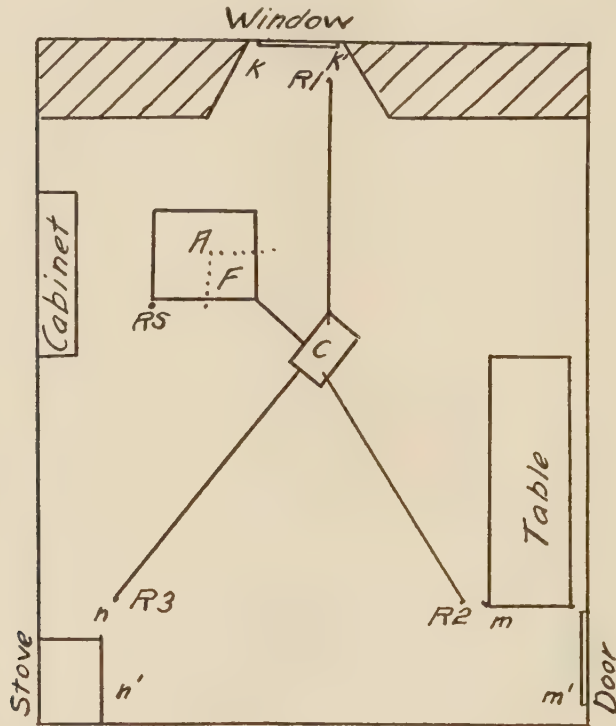


FIG. 6B

Test. A—around on table—A—top of cage (30)—A—around table—A (55)—tries sides of cage—A (100)—top of cage—A (125)—tries to get under sides of cage (140)—looks down from table (150)—A—looks down from table (170)—top of cage—A (190)—RSh (200)—down RS (205)—runs zig-zag about room, very active—comes within one meter of R1—R2 (245)—up R2—c—path 3—R3h—c—F (280).

2. A—down RS (9)—toward screen—R3 (30)—up—F (39).

3. A—down RS (3)—near door (15)—within 1 meter of R1—to RS

and up (27)—A—down RS (42)—toward screen—R3h (70)—to R2 and up (80)—c—path 1—R1h (97)—c—F (107).

Set-up 6b. Learns from 2 points on floor.

Test. 1. A—around table—RSh (15)—around table—A (25)—RSh—down RS (35)—floor (37)—up RS again (47)—A—down RS (61)—floor (65)—near window (70)—R1 and up (77)—F (87).

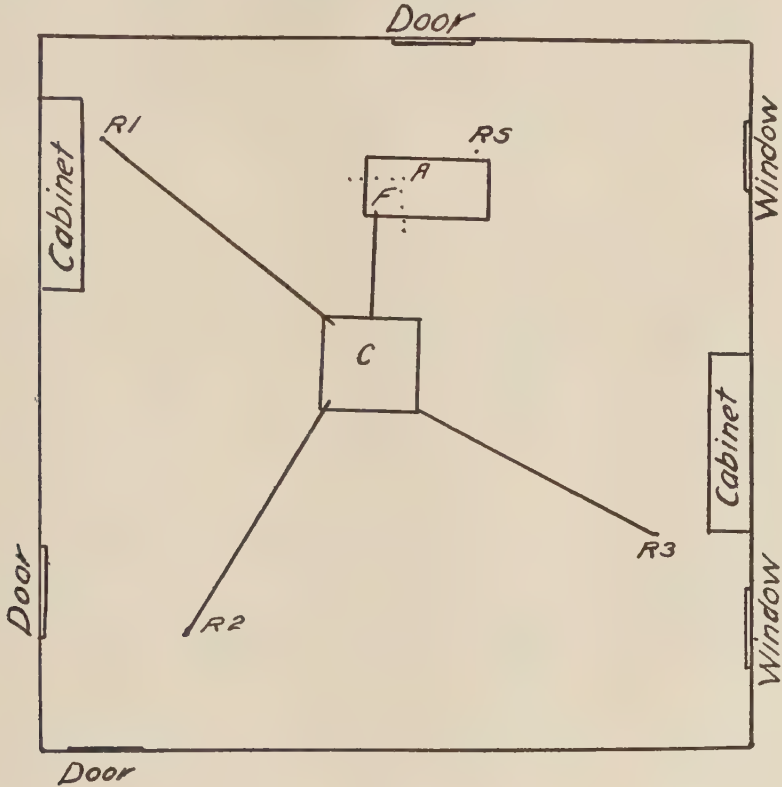


FIG. 6c

2. A—down RS (9)—floor (12)—quite direct to R1 (21)—F (30).

Set-up 6c. Learns from 2 points on floor.

Test. 1. A—around table and at cage—down RS (67)—floor (71)—under c—wanders within $1\frac{1}{2}$ meters of R1—under table A—around in that vicinity—RSh (125)—toward window side of room—washes—taken up (190).

2. A—down RS (31)—floor (35)—left toward door side of room—back of room—R1 (49)—F (66).

3. A—floor (26)—direct to R1 (35)—F (52).

TABLE 5
Second run in parenthesis

SET-UP	RAT	TIME BEFORE ON FLOOR	TIME ON FLOOR	PATH TAKEN		
				First run	Second run	Third run
		<i>seconds</i>	<i>seconds</i>			
6a	A	205 (9)	40 (21)	2	3	2
	B	10 (7)	123* (40)	2	2	2
	C	10 (26)	40 (17)	1	1	3
6b	A	35 (9)	28* (9)	1	1	1
	B	39 (8)	16 (13)	2	2	2
	C	35 (8)	37* (12)	1	3	3
6c	A	85 (23)	161† (12)	0	1	1
	B	28 (17)	197 (9)	1	1	3
	C	15 (26)	70 (5)	1	1	3
Average.....		51 (15)	79 (15)			
Number of times learned path is taken.....				3 33.3%	5 55.5%	7 77.8%

* The rat returned to A after having been on the floor. Only the actual time on the floor is counted.

† In the first run the rat did not find the food, but apparently gave up. This value is the time on floor for both runs. This run has been given in detail above.

TABLE 6

	TIME BEFORE ON FLOOR	TIME ON FLOOR	NUMBER OF TIMES CORRECT PATH IS TAKEN		
			First run	Second run	Third run
	<i>seconds</i>	<i>seconds</i>	<i>per cent</i>	<i>per cent</i>	<i>per cent</i>
Unfamiliar room.....	51 (15)	79 (15)	33	55	77
Familiar room.....	46.5 (13)	12 (6.9)	100	100	

The main facts of the results are given in table 5.

In these "set-ups" we find that the rats only find the ringstand that they learned to take, one third of the time. In the second

and third runs this value increases. This type of variation was not present in the preceding experiment.

We bring the results of table 4 and table 5 together in table 6.

In set-up b of this experiment (fig. 6b) the rats were placed at point X. Rats A and C went to A and then to the path they had been taught. On the next trial both went direct to the pathway. Rat B went directly to the pathway on the first run. It should be noticed that the rats did very well in this room and that after the first run from A, all made perfect runs. Before being placed at X each rat had made 5 runs from A.

Experiment 2 (2)

Experiments E and F are repeated in experiments 2 and 3. For part of the experiments in a known room the university of Michigan maze platform was used, for the remainder, rooms were used as in the above mentioned experiments. In some of the later "set-ups" only 3 of the rats were shown a path to food, the other 3 could only come upon one of the paths by chance. By the time this control group was used the rats were familiar with the situation and were in the habit of exploring the floor until a path was found.

A series of 7 "set-ups" was used on the maze platform. Figure 7a shows the platform and the position of the ringstands in one of the "set-ups." In each "set-up" there were 3 possible routes to F (R1, R2, and R3). The crosses represent piles of board sections (normally used for walls of the maze) which were present to give character to the situation. The wire cage separates A (starting point in test) from F (position of food). RS is the ringstand which leads from the starting table to the platform floor.

Before the experiment the rats were allowed to become familiar with the maze platform and the long elevated table A. As they seemed a bit slow in learning to use the ringstands, small wire ladders were fastened to the ringstands. These they soon learned to use without fear. Thus preceding the experiments the rats learned to use the ladders and also to crawl up an inclined pole to F where they were always fed.

One "set-up" was used each day and was made as different as possible from that of the previous day. Before the new "set-up" was built each day, the rats were allowed to explore the situation for a couple of hours. This probably removed all carrying-over tendencies from the day before.

The rats were divided into 3 groups of 2 each. Each group learned a different pathway.

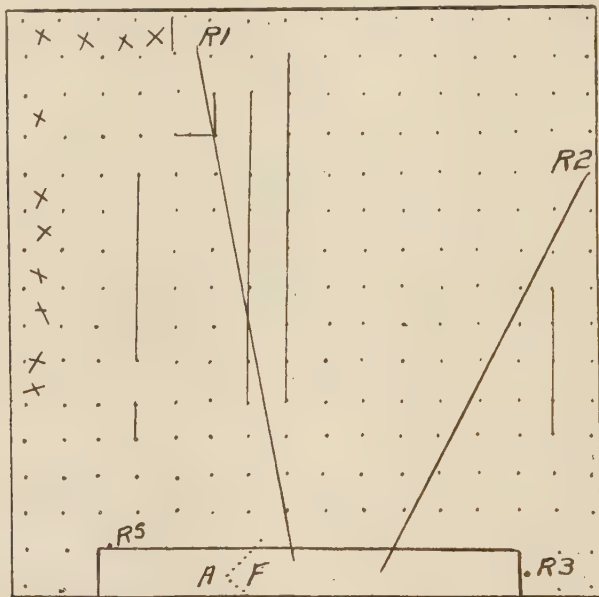


FIG. 7A. (TYPICAL "SET-UP")

● = posts on maze floor. X = piles of board sections. R1, R2, and R3 = ring-stands. Parallel lines = maze alleys set-up.

The results for each "set-up" will be given rather than the results for each rat. As some of the rats made errors, the time on the floor for both correct and wrong runs will be given. Figures in parenthesis show the number of each such cases. The number of rats taking the path they were shown will be given for the first two runs. The results are given in table 7.

The rats were also started from some point x on the maze, that

TABLE 7
Maze platform familiar. Starting from A

SET-UP	AVERAGE TIME BEFORE ON FLOOR	AVERAGE TIME ON MAZE FLOOR IN FIRST RUN		NUMBER OF TIMES CORRECT PATH IS TAKEN	
		Correct	Wrong	First run	Second run
	<i>seconds</i>	<i>seconds</i>	<i>seconds</i>		
7a	32.0	50.2*	115.0 (2)	4	4
7b	8.7	17.4	25.0 (1)	5	5
7c	13.3	23.0	29.0 (1)	5	6
7d	5.8	7.6		6	6
7e†	8.0	7.0	53.0 (1)	4†	4
7f	12.0	10.5	42.5 (2)	4	4
7g	9.3	17.8		6	6
Average (41 runs)	12.8	19.4	61.4 (7 cases)	82.9%	85.4%

* Rat 50 used 68 seconds most of which was spent in washing. It, however, took the correct path, but considerably raised the average time for correct runs.

† Rat 47 was indisposed. Only 5 rats ran. Hence final averages are computed for 41 rather than 42 cases.

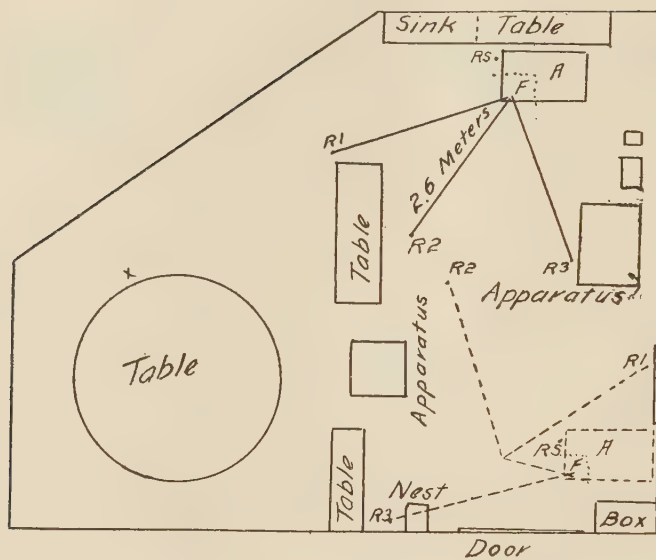
TABLE 8
Starting from X

SET-UP	NUMBER OF CORRECT RUNS	AVERAGE TIME USED TO REACH RINGSTAND	
		Correct runs	Wrong runs
		<i>seconds</i>	<i>seconds</i>
7a	6	11.3	
7b	3	8.6	10.3 (3)
7c	5	9.4	21 (1)
7d	6	4.8	
7e	5*	6.0	
7f	5	6.4	14 (1)
7g	6	11.2	
Average (41 runs) ...	87.8%	8.3	13.2 (5 cases)

* Only 5 rats in this group.

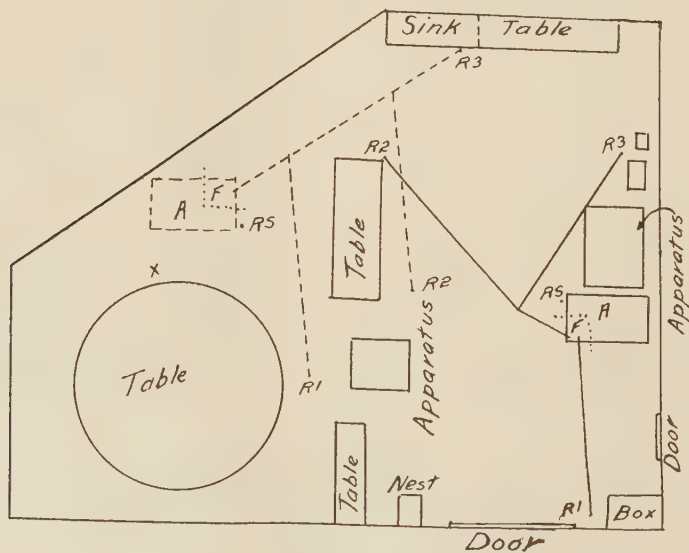
TABLE 9

	RAT 44	RAT 46	RAT 47	RAT 48	RAT 49	RAT 50	TOTAL
Errors.....	0	1	1	3	2	0	7



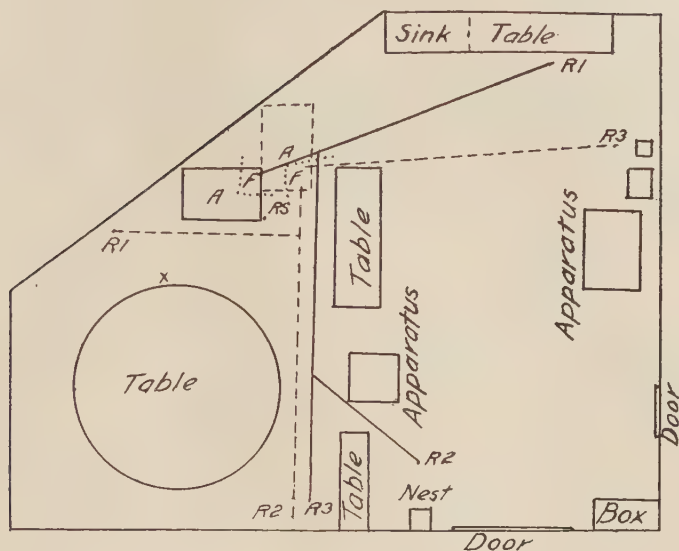
Set-up a ———. Set-up b ----

FIG. 8A AND B



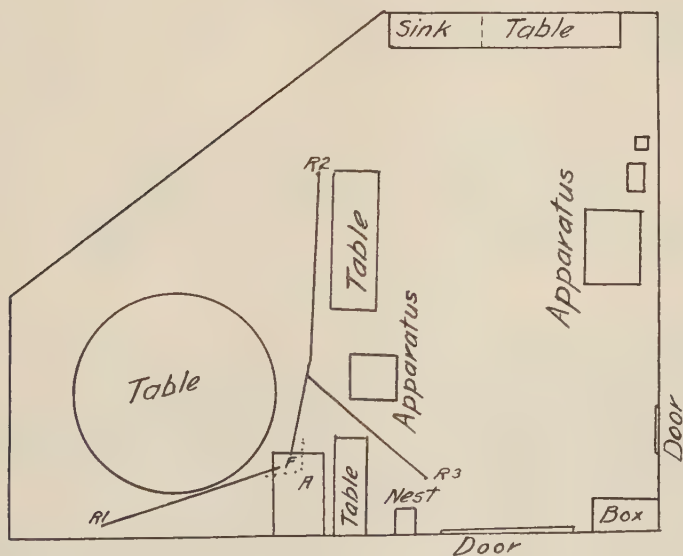
Set-up c ———. Set-up d ----

FIG. 8C AND D



Set-up e ———. Set-up g ----

FIG. 8E AND G



Set-up f

FIG. 8F

was not in line with the territory covered in going from A to one of the paths.

If the rat took the same pathway (ringstand) that it took in the 3 preceding runs, going from A, the run was considered correct; if it took a different ringstand, the run was considered wrong.

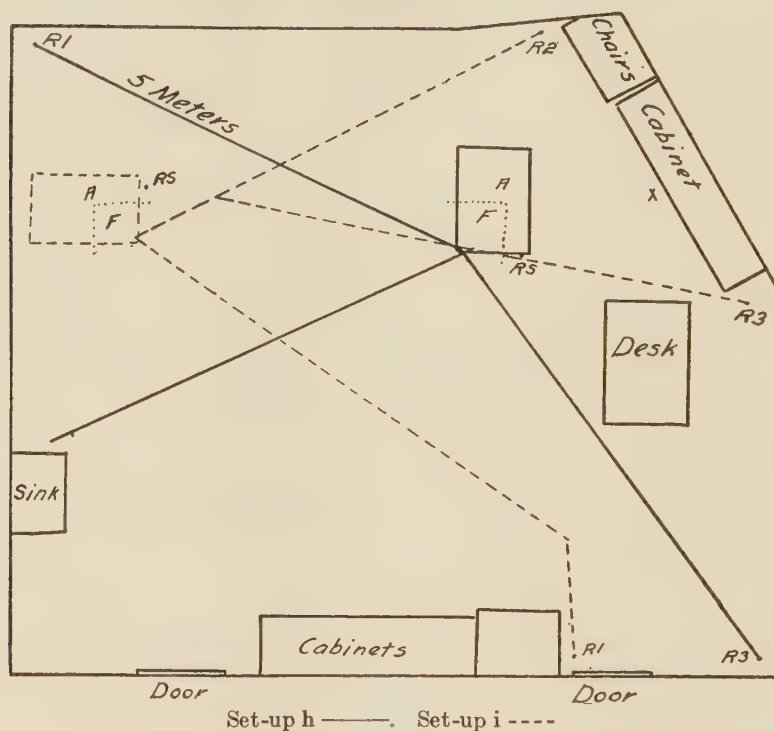


FIG. 9H AND I

The time for these runs, from the point placed to the ringstand, was also taken. The results are given in table 8.

In table 7 we find that 7 errors were made when the rats had to find their way from A to F. Table 9 shows how these errors were distributed among the different rats.

In a group of 11 "set-ups" two different rooms were used. Figures 8a, 8b, 8c, 8d, 8e, 8f, and 8g show the arrangements in one of the rooms, and figures 9h, 9i, 9j, and 9k in the other room.

Experiment 3 chronologically falls between these two groups of experiments.

The rats were given three days in which to become familiar with each of the rooms. They were fed at F during this time, having to leave from A and find the ringstand that supported

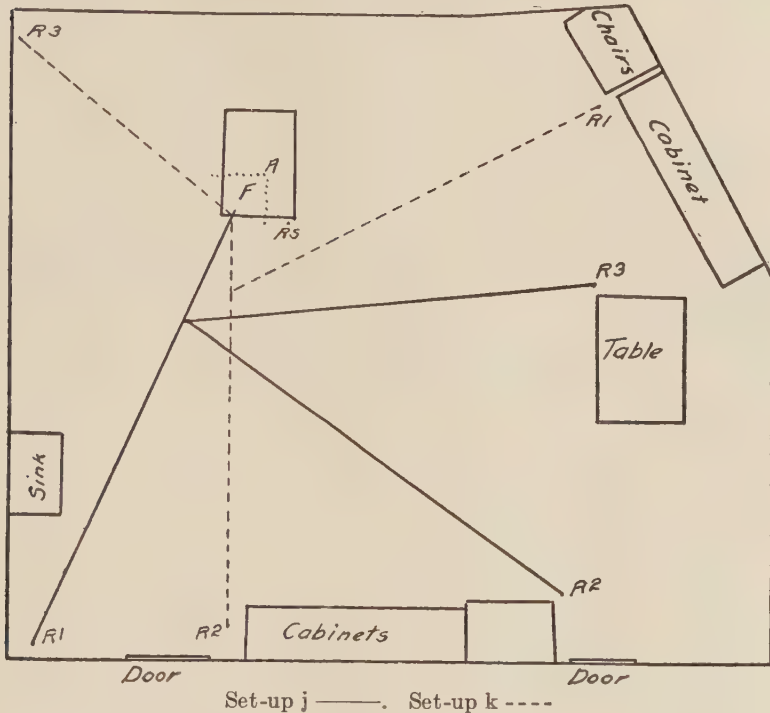


FIG. 9J AND K

the pathway that lead to F. Table A was 1.2 by 0.8 meter in size. As usual the light stimulus was placed next to the food.

To test the possibility of olfaction in finding the ringstand that had been learned, the ringstands were often interchanged after the learning of one of them. This precaution did not affect the test run in any manner.

For these experiments the rats were divided into two groups. Rats 44, 47, and 49 made up one group and rats 46, 50 and 51⁵

⁵ Rat 48 indisposed. Rat 51 substituted.

TABLE 10
Rooms familiar

SET-UP	AVERAGE TIME BEFORE ON FLOOR	AVERAGE TIME SPENT ON FLOOR IN FIRST RUN			NUMBER OF RATS RETURN- ING TO A	NUMBER OF TIMES CORRECT PATH IS TAKEN
		All runs	Correct	Wrong		
Path from R to F learned						
	<i>seconds</i>	<i>seconds</i>	<i>seconds</i>	<i>seconds</i>		
8a	24	11.3	11.3		0	6 (6 cases)
8b	21.3	11.6	11.6		0	3 (3 cases)
8c	13	7.3	3.5	15 (1)	0	2
8d	24.6	12	12		0	3
8e	13	13	13		0	3
8f	25.6	9	5	17 (1)	0	2
8g	11.6	5.6	5.6		0	3
9h	13.6	19.6	19.6		1	3
9i	17.3	10.3	11.5	8 (1)	0	2
9j	16	12	12		0	3
9k	11	9	5.5	16 (1)	0	2
Average (36 cases)	17.4	11	10	14 (4 cases)	2.8%	88.9%
Path from R to F not learned						
8a						
8b	22.6	33.7			1	
8c	31	28.6			1	
8d	21.3	42.6			1	
8e	10.3	145.6			2	
8f	41.6	42.6			1	
8g	12.6	304.3			1	
9h	11	50.3			2	
9i	13.6	40			0	
9j	38.3	20			0	
9k	14.3	22.3			0	
Average (30 cases)	21.7	73			30%	

TABLE 11
Average time for the 2 groups of rats

TRAINING	TIME BEFORE ON FLOOR	TIME ON FLOOR		
		First run	Second run	Third run
	<i>seconds</i>	<i>seconds</i>	<i>seconds</i>	<i>seconds</i>
R to F learned.....	17.4	11	6.5	5.6
R to F not learned.....	21.7	73	8.4	6

TABLE 12

Familiar rooms. Time and correct runs in going from X to R

SET-UP	NUMBER OF TIMES CORRECT PATH IS TAKEN	TIME IN GOING FROM X TO F		
		All runs	Correct	Wrong
R to F learned				
		<i>seconds</i>	<i>seconds</i>	<i>seconds</i>
8a	6 (6 cases)	17.2	17.2	
8b	3 (3 cases)	6.3	6.3	
8c	3	3.3	3.3	
8d	3	5.3	5.3	
8e	3	11	11	
8f	3	5.3	5.3	
8g	3	4.6	4.6	
9h	3	8.3	8.3	
9i	3	12.3	12.3	
9j	2	7.6	4	15 (1 case)
9k	2	10.6	6	20 (1 case)
Average (36 cases).....	94.4%	8.3	7.6	17.5 (2 cases)
R to F not learned				
8a				
8b	2	11	7.5	18 (1 case)
8c	2	5	4	7 (1 case)
8d	3	8.3	8.3	
8e	2	7.3	7	8 (1 case)
8f	3	5.6	5.6	
8g	3	7	7	
9h	2	10.6	10	12 (1 case)
9i	3	19.6	19.6	
9j	3	9.6	9.6	
9k	3	7.6	7.6	
Average (30 cases).....	86.7%	9.1	8.6	11.2 (4 cases)

TABLE 13

Record of each rat in the 11 set-ups. First run

	RAT 44	RAT 46	RAT 47	RAT 49	RAT 50	RAT 51	AVER- AGE
Errors.....	1	2	0	1	0	0	.67
Time on floor, R to F learned, seconds.....	8.8	12.5	11.3	17.2	12.2	8.3	11.7*
Time on floor, R to F not learned, seconds.....	35	36.5	40.8	34	65	229.4	74.3*

* The total averages are not identical with those of table 10, because in the 11 set-ups, some of the rats learned R to F in 6 set-ups, and some in 5 set-ups.

the other. Each day each rat of one of the groups learned one of the three paths (ringstand to F, as has already been described in experiment E), the other group was not allowed to learn a path. The two groups alternated as to learning or not learning from day to day. Only in "set-up" 8a were both groups shown a pathway. The control rats were placed at F for a bite to eat before testing, in order to equalize any effect that eating might have.

In the results it was noticed that the rats often returned to A after having gone to the floor (in experiment F this was also found to be the case), hence the number of rats returning to A in each "set-up" is also given in the table in order to show whether or not this behavior had anything to do with knowing or not knowing the pathway R-F.

Tables 10, 11, 12, and 13 give the results of the 11 "set-ups" in the familiar rooms.

Table 11 gives the time spent on the floor in the first three runs, as well as the time before going to the floor, for each of the two groups of rats.

After the three runs the rats were also placed at some point on the floor, designated as X in the figures 8 and 9. If the rat continued to take the path it had taken in starting from A, then the run was considered correct. Thus scores could be taken for both groups, as the group not trained to R-F had, by this time, learned to go to one of the paths. In table 12 the number of correct runs and the average time in going from X to R are given for each "set-up." The time for erroneous and correct runs is also given.

In table 13, the time in going from A to R and the number of times the wrong R (ringstand) was taken, in the 11 "set-ups," is given for each individual rat.

Tables 10 and 11 thus show that a knowledge of b-F is an important factor in the first test run. After the first run the rats have themselves acquired a knowledge of b-F and are thereafter no longer handicapped as tables 11 and 12 show.

Experiment 3 (3)

The procedure in this experiment was the same as in experiment 2. Instead of familiar rooms, unfamiliar rooms were used.

The 10 "set-ups" shown in figures 10a, 10b, 10c, 10d, 10e, 10f, 10g, 10h, 10i, and 9h were used in the order given. As this series of experiments just preceded the series 9h, 9i, 9j, and 9k, it was possible to use set-up 9h, first as in an unfamiliar room, and

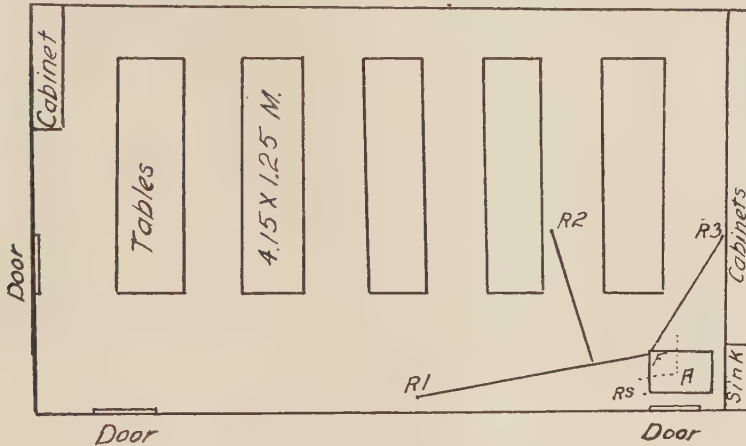


FIG. 10A

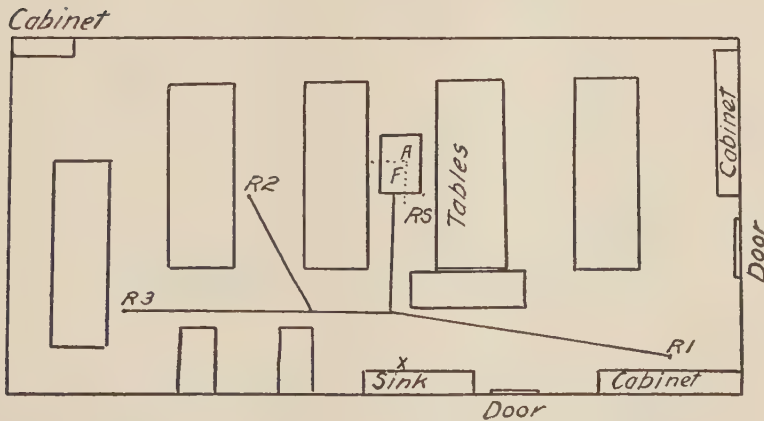


FIG. 10B

then after three days, to use it as in a familiar room. During the 3 days intervening, the set-up was of course removed, and the rats given the freedom of the room.

Before beginning this series of experiments the rats were fed

in different rooms the three days preceding, and the fear of strange rooms apparently entirely removed.

The results are given in tables 14, 15, 16, and 17.

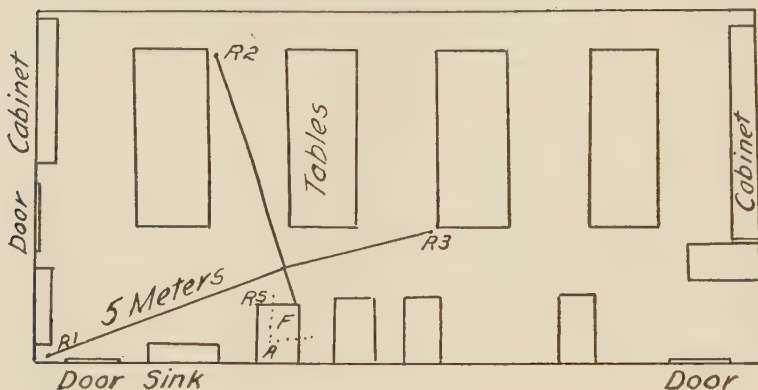


FIG. 10c

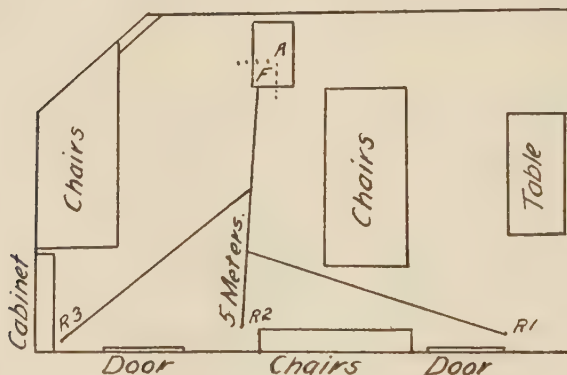


FIG. 10d

Table 15 gives the time spent on the floor in the first three runs, as well as the time before going to the floor, for each of the two groups of rats.

After the three runs the rats were placed at some point on the floor at point X. If they took the same ringstand that they had been taking, the run was counted as correct, if a different one, wrong. These results are given in table 16.

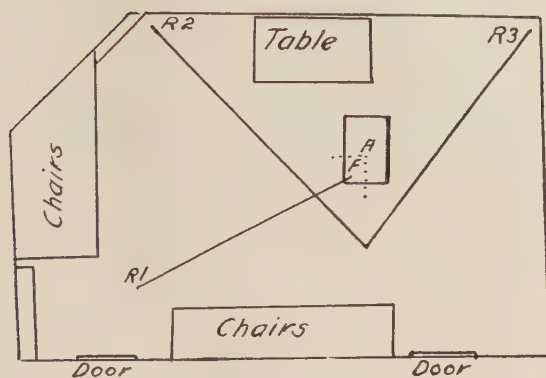


FIG. 10E

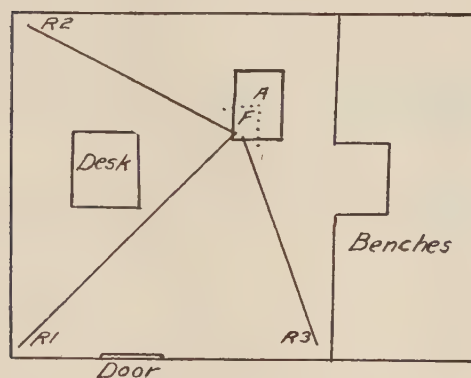


FIG. 10F

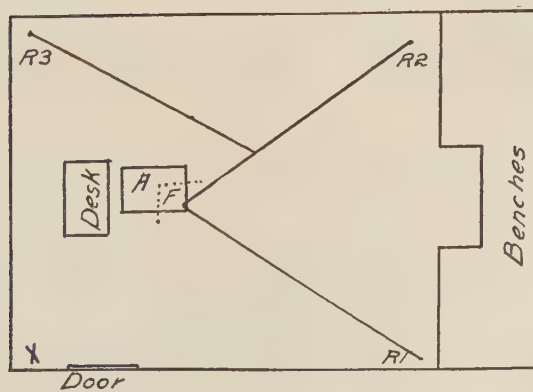


FIG. 10G

In table 17, the individual record, for the 10 "set-ups" in unfamiliar rooms, is given.

In unfamiliar rooms, where the knowledge of the rat is incomplete, a knowledge of b-F ceases to be an advantage as in the preceding experiment.

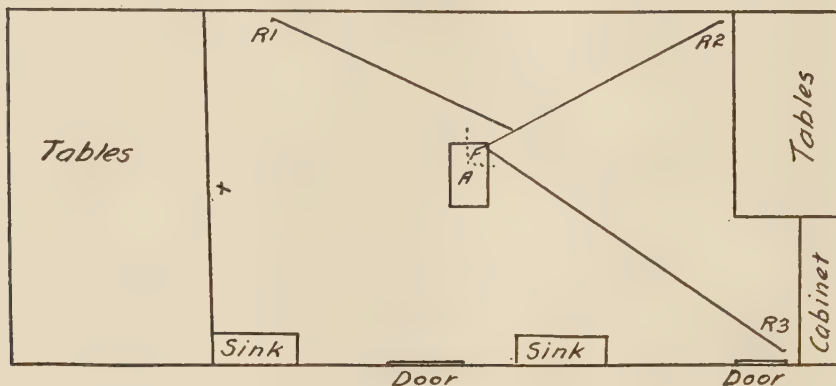


FIG. 10H

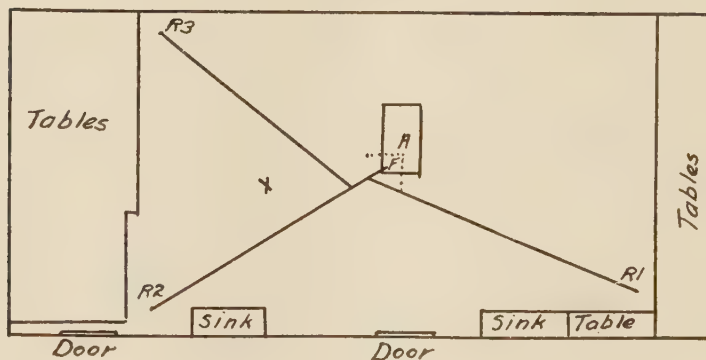


FIG. 10I

Experiment 4

To check the importance of lighting as a cue for the rat's orientation, certain lighting changes were introduced in the situation where the rat had to find the beginning of a path on the maze platform ("set-ups" similar to those in experiment 2). The rat learned the maze platform with the source of light directly over

TABLE 14
Rooms not familiar

SET-UP	AVERAGE TIME BEFORE ON FLOOR	AVERAGE TIME SPENT ON FLOOR IN FIRST RUN			NUMBER OF RATS RETURN- ING TO A	NUMBER OF TIMES CORRECT PATH IS TAKEN
		All runs	Correct	Wrong		
Path R to F learned						
	<i>seconds</i>	<i>seconds</i>	<i>seconds</i>	<i>seconds</i>		
10a	30.7	133.7	133.7		3	3
10b	26.7	89	118.5	30 (1)	1	2
10c	25	45.6	28.5	80 (1)	1	2
10d	22.3	338	338		2	3
10e	21.3	50.3	34	58.5 (2)	0	1
10f	66	58	66	42 (1)	0	2
10g	27	32		32 (3)	0	0
10h	59	64.3	64.3		0	3
10i	44.6	50	59	45.5 (2)	0	1
9h	32.3	24.3		24.3 (3)	0	0
Average (30 cases)	35.5	88.5	124 (17 cases)	40.7 (13 cases)	23.3%	56.7%
Path R to F not learned						
10a	62	122.7			2	
10b	59.3	146.3			2	
10c	19.6	90.6			1	
10d	27.6	229			3	
10e	27.3	77.6			0	
10f	47	90			1	
10g	36	57			3	
10h	31	35.3			0	
10i	104.3	41			0	
9h	35.3	31.6			0	
Average (30 cases)..	44.9	92.1			40%	

TABLE 15
Average time for the 2 groups of rats. Unfamiliar rooms

TRAINING	TIME BEFORE ON FLOOR	TIME ON FLOOR		
		Third run	Second run	Third run
R to F learned.....	35.5	88.5	17.1	8.4
R to F not learned.....	44.9	92.1	14.6	7.6

one of the corners. Two types of variation were then introduced. (1) The rat learned the beginning of the pathway (R) to F with the lighting as described above and was tested with the light-

TABLE 16
Unfamiliar rooms. Time and correct runs in going from X to R.

SET-UP	NUMBER OF TIMES CORRECT PATH IS TAKEN	TIME IN GOING FROM X TO F		
		All runs	Correct	Wrong
R to F learned				
		<i>seconds</i>	<i>seconds</i>	<i>seconds</i>
10a	2	85	85	85 (1)
10b	3	27.3	27.3	
10c	3	32	32	
10d*	2	25.7	26	25 (1 case)
10e	3	10.3	10.3	
10f	3	30	30	
10g*	2	21.3	26.5	11 (1)
10h	2	50	51.5	47 (1)
10i	3	24	24	
9h	2	16.3	17	15 (1)
Average (30 cases)...	83.3%	32.2	30.9 (25 cases)	36.6 (5 cases)
R to F not learned				
10a	2	67.3	85	32 (1)
10b	2 (2 cases)	62.5	62.5	
10c	2	27.6	55	10 (1)
10d	2	19.6	20	19.5 (1)
10e	2	17.3	18	16 (1)
10f	3	47.3	47.3	
10g	3	20.6	20.6	
10h	1	49	75	36 (2)
10i	2	32.3	12.5	72 (1)
9h	2	20.3	21.5	18 (1)
Average (29 cases)...	72.4%	35.5	39.4 (21 cases)	29.9 (8 cases)

* Rat does not take ringstand it comes to first, but leaves to find a different one. Data is handled as if the first R were taken.

ing just reversed (source over the opposite corner). (2) The lighting just reversed during the learning of R to F, but normal for the test.

Lighting changes were later introduced in strange rooms, the lighting being reversed between the learning and the test series. The path-ways were placed opposite to each other so that if lighting was the determining cue it would encourage errors.

The results showed no difference between the group used as control and the group that had lighting changes introduced. In some rooms, both groups made no errors, in other rooms both had the same amount of difficulty.

Experiment 5 (8)

After experiment 8 a series of experiments was carried out to determine the more specific cues by means of which the rat ori-

TABLE 17
Record of first run, for each rat, in unfamiliar rooms

	RAT 44	RAT 46	RAT 47	RAT 49	RAT 50	RAT 51	AVER- AGE
Errors.....	2/6†	1/4	4/5	2/5	3/5	1/5	0.43
Time on floor, R to F learned, seconds.....	46.2	46	71.4	83.2	95.2	212.4	92.5*
Time on floor, R to F not learned, seconds.....	95.7	61.8	134.6	89.8	105	102.6	98.2*

* These figures do not check with the total averages in table 14 because rat 44 was shown the path R-F in 6 set-ups and rat 46 in 4 set-ups, instead of 5, as for the other rats.

† Numerator gives the number of errors, the denominator, the number of cases in which the rat was shown R-F, and so could have made an error.

ents and finds its way about a room. The room used was the one shown in figure 8. The variations in the set-ups were similar to those in previous set-ups, so the specific set-ups used in these experiments need not be included.

Instead of three, two pathways led to food in these experiments, part of the rats being shown one of the pathways, part the other. This naturally increased the time necessary for chance solutions, but made the possibility of finding the correct ringstand (by chance) 50 per cent rather than 33.3 per cent.

The position of A remained constant.

In a series of 4 set-ups, part of the rats were shown one of the

ringstands in the light (ran from R to F three times) and then were tested (starting from A) with the room completely dark; the rest of the rats were used as controls, learning the pathway (R to F) as the other group and tested with the lighting normal. The two groups were alternated from day to day except rat 44 which was always in the test group.

The time that the rat used on the floor was taken from the sound that the rat made in going down the wire ladder at A and going up the ladder at R. The light was turned on as soon as the rat was heard to climb up R so that it could be seen which ringstand the rat found. As the rats do not immediately climb up the ringstand on reaching it, the time on the floor will be somewhat greater.

Two runs were made by each rat. Those running in the dark were given an additional run with the lights on.

In the control group, 3 rats were used each day, making a total of 12 tests. The average time for the first run was 14 seconds, the shortest run being 5 seconds, the longest 22 seconds. The average time for the second run was 10.9 seconds, or only 3.1 seconds less than the first run. The pathway that was shown the rat was taken 100 per cent of the time. (The rats were thoroughly familiar with the room and so made no errors).

A total of 16 tests were made in the dark, 4 rats being run each day. The average time for the first run was 33.4 seconds with a range of 7 to 98 seconds. As 3 of the 16 runs were unusually long, being 98, 85, and 57 seconds, the average is unusually large. If these 3 runs are disregarded, the average time becomes 22.7 seconds with a range of 7 to 32 seconds. The average time for the second run was 22.1 seconds. With the lighting normal for the third run, the time was 18.2 seconds. The correct pathway was taken 100 per cent of the time.

In the next group of 4 set-ups, in 16 cases rats were shown one of the pathways in the dark and then tested in the light, and in 12 cases they were used as controls as before. In the control group 91.7 per cent of the rats took the correct path. The average time for the correct runs was 6.8 seconds and for the wrong run 15 seconds. These times for second runs were 4.8 and 6

seconds respectively. Of the rats learning the pathway in the dark 87.5 per cent went by way of the correct pathway. The time for the correct runs was 10.7 seconds and for the wrong 49 seconds. On the second run these values were 6.1 seconds and 10.5 seconds.

In the next 4 set-ups the ringstands were placed so as to be more than 50 cm. from an object or a wall. In learning the pathway, the rat was not allowed to investigate in the vicinity of the ringstand. Part of the rats thus restrained were started from the base of the ringstand, and part were started from the top of the ringstand. All learning and tests were in the light.

Of the 15 rats which were shown the pathway from the base of the ringstand, 86.7 per cent took the pathway learned. The time for the correct runs was 21 seconds and for the wrong 47.5 seconds. Of the rats making correct runs, 1 out of 13 or 7.7 per cent returned to A after starting, and of those making wrong runs, 1 out of 2 or 50 per cent returned to A.

Of the 13 rats learning the pathway from the top of the ringstand, 38.5 per cent took the correct path and 61.5 per cent the wrong. The average time on the floor for the correct runs was 55.2 seconds and for the wrong runs 39.5 seconds. The number of rats which made correct runs and returned to A was 1 out of 5 or 20 per cent and the number which made wrong runs and returned to A was 2 out of 8 or 25 per cent.

In a series of 7 "set-ups" the ringstands were again so placed as to be a considerable distance from any object. The rats were held by the tail so as not to be able to investigate about the ringstand. Part of the rats thus learned a pathway in the light and part in the dark. (In one of the "set-ups" one rat was indisposed.)

Of the 27 rats that learned the pathway in the light 74.1 per cent took the correct path. The time for the correct runs was 21.6 seconds and for the wrong 42.9 seconds. The number of rats returning to A was 1 out of 20 or 5 per cent for the correct runs and 3 out of 7 or 43 per cent for the wrong.

Of the 21 rats learning the pathway in the dark only 47.6 per cent took the correct pathway. The time for the correct runs

was 31.8 seconds and for the wrong 36 seconds. The number of rats which returned to A was 2 out of 10 or 20 per cent for the correct runs and 4 out of 11 or 36 per cent for the wrong runs.

A few experiments were conducted in which a familiar object in the room was moved and a pathway then placed near this object in the new position. In a few cases the rats went directly to where the object had always been, in more cases the rat went quite directly to the new position of the object, but in most cases there seemed to be confusion. If the rat can recognize a position in the room as a whole and if it also uses familiar objects to orient itself, this might be expected. As some objects serve as better landmarks than others, and as certain rooms and certain positions in the same room have more character than others, consistent results were difficult to obtain. The rats were most likely to go to the old position of an object when tested in a room that had little furniture.

The vibrissae of three rats were then cut. This group and a control group of three rats were shown one of two possible paths to F in the dark, the path beginning near a characteristic object. The test run was made under the normal lighting conditions.

The first day, just after the vibrissae had been cut, there was a marked difference in the behavior of the two groups. The rats without vibrissae went about somewhat confused, ran slowly and carefully. They were inclined to run into small obstacles.

In the test, 2 of the rats went wrongly, the time being 23 and 73 seconds. The time for the 1 making a correct run was 22 seconds. All 3 rats of the control group took the correct path, the times being 10 seconds, 38 seconds, and 11 seconds.

The following three "set-ups" showed no such difference, both groups going correctly 87.5 per cent of the time. The average time on the floor for the control group was 17 seconds, and for the other group 15.5 seconds. The wrong run for the control group required 70 seconds, and for the other group 36 seconds.

Experiment G (3, 4, 5, and 6)

The purpose of this experiment was to find whether or not a rat would use the floor in order to bridge a gap between itself and

the food. As this experiment chronologically follows experiment B the rats were entirely unfamiliar with the floor. This must be kept in mind in considering the results.

Because of limited space only a general statement of the results will be given.⁶

Set-up no. 1. A "U" shaped pathway with square corners was used. It was supported by four ringstands and could gradually be lowered until it rested on the floor. Food was then placed on a small platform at one extreme and the rat started from a small platform at the other extreme. After each run the platform was slightly lowered.

The results may be summarized as follows:

1. The floor was used as soon as the pathway was between 5 and 10 cm. from the floor.

2. When going to the floor the rats had no decided orientation as to the position of the food.

3. The pathway seemed to be used as a guide on the floor. In first attempts on the floor the pathway was often followed: the rat running under or alongside of the pathway.

4. Direct short-cuts on the floor to the food were found after 2 or 3 runs on the floor, the first attempts being mainly within the "U" and less direct.

5. By placing the rats at different points along the pathway other short-cuts were obtained. Of interest is the fact that great variety was shown in the different runs of the same rat.

6. On elevating the pathway again the rats often jumped to the floor to take the short-cut on the floor. (They did not fall, but jumped after considerable hesitation.) They also showed a decided tendency to alternate between going around the pathway and using the floor.

Set-up no. 2 and 3. The corners of two tables were placed against each other and so separated by a wire cage that a rat could not cross from one to the other. Ringstands were placed along side the tables, and by the use of these the rat could get from one table to the other. The room was perfectly familiar and also the

⁶ Detailed results are on record in the University of Michigan Graduate School.

ringstand at the food-table. Food was then placed on one table and the rat started from the other. On the following day the starting point and the position of the food were just reversed.

The results show considerable "trial and error" manipulation at the wire at the point nearest the food, but when the floor was resorted to, the trip was direct. That is, there was no evidence of wondering about the floor even though the ringstands were as far as 10 feet apart. (The large table in figure 1 was used.)

The following is the behavior of rat C when first presented with this problem.

1. At cage—looks down to floor (45 sec.)—washes (50 to 60 sec.) looks down to floor (70)—reaches through cage at food with fore-foot—looks down toward floor (150)—climbs on cage (160)—digs at paper under cage trying to get under—bites and pulls at paper (200)—climbs on cage (210)—looks down (220)—tears at paper (240)—bites wire—tries climbing around cage (260)—at point nearest food (270)—suddenly turns about, goes to ringstand, and climbs down (280)—floor (290)—under large table and up ringstand (310)—climbs over wall which divides table into two halves—food (327).

2. At cage—washes—down ringstand (10)—up ringstand at other table—(30)—food (44).

With food and starting point reversed the results are equally positive.

In a third set-up using two tables with slightly modified conditions, the results obtained were about the same. With more than one ringstand next to the food-table, variations in the different runs appeared. That is, different ringstands were used to make the trip in different runs of the same rat.

Succeeding runs reduced the time spent at the cage before the floor was used; the time on the floor, however, showed little or no reduction.

Experiment H (7)

In the three preceding set-ups of experiment G the rats had to descend from the table in order to reach the food, in this experiment it was necessary to get over a barrier. The "set-up"

used is shown in figure 11. The food was placed within a wire cylinder 35 cm. in diameter and 60 cm. high and is designated by the circle shown in broken lines in the figure. To prevent the rats from crawling over the top of the cylinder, a pasteboard collar was fitted around the middle of the cylinder. In part of the experiment, F could be reached by the rat's climbing up a pole erected near the cage (indicated by R5), then across n, and

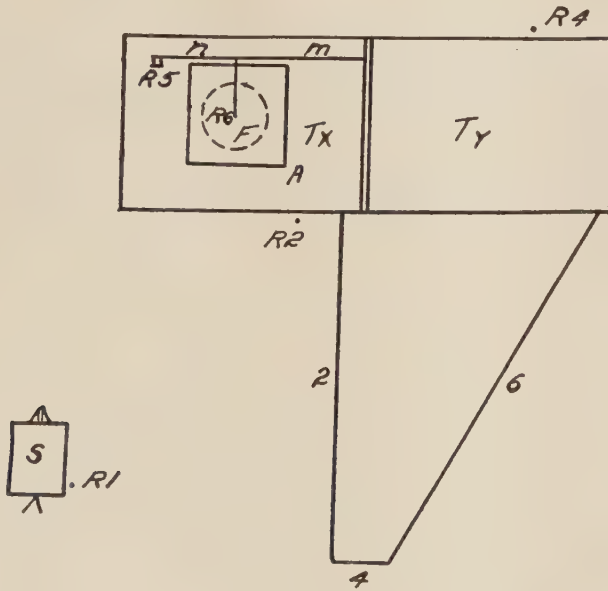


FIG. 11

down the ringstand R6. In the remainder of the experiment, R5 and n were removed and m was placed from the top of wall to the cylinder. Thus the rat had to climb to the top of the wall, go across m, and down R6.

R2 and R4 are still present from experiment G so that the effects of the previous experiments can be shown. The pathway 2, 4, 6, gives opportunity for exploration. The rats were not placed on the table before the experiment.

Results:

Rat B. R5 and n present, m not present.

1. A—circles cylinder—R5h—R2h (16)—circles cylinder—R2h (20)—2—4—6—around Ty—6 (66)—4—2—Tx (75)—up R5 (80)—n—around on top—tries to get down side of cage—n—down R5 (130)—Tx—down R2 (136)—around on floor—up R2 (160)—R5h (170)—up R5 (173)—n—down R6 (187)—F (190).

2. A—around cylinder—2—6—over wall at r (30)—A—R5h—up R5 (40)—down R6 (50)—F (54).

R5 and n removed, m substituted.

3. A—looks for R5—R2h (20)—around cylinder—2h—2 (35)—4h—Tx—A (50)—looks for R5—down R2 (75)—up R1 (85)—s—down R1 (105)—up R4 (120)—6—4—2—Tx (135)—tries to climb up cylinder (150)—looks for R5 (160)—around on Tx—2 (180)—4—6—Ty—over wall at r—and notices m (210)—m—down R6 (225)—F (227).

4. A—around cylinder—2 (15)—4—6—Ty—wall at r (30)—m—down R6—F (40).

5. A—around cage—R2h—wall at R (20) (did not go to Ty) m—down R 6—F (32).

Rat A. Set-up remains the same for the remainder of the experiments. (Path m present.)

This rat was shown part of the way to F by being placed at the beginning of m before the experiment and as it was not allowed to go backward soon found the food. This was repeated a second time with the rat placed at the junction of m and the wall (thus having a chance to recognize the wall).

1. A—around cylinder—2h—2 (20)—4h—4—6—Ty (40)—6—4—2—Tx (55)—around cylinder—R2h (69)—2h—around Tx—2 (105)—4—6—Ty—6h—tries to get up wall directly under m (125)—finally gets on top of wall at r—m (135)—down R6—F (150).

2. A—2—4h—4—6—Ty (24)—top of wall at r (30)—m—down R6—F (40).

3. A—around cylinder—2h—R2h—around cylinder—tries to crawl over cylinder (30)—wall r (37) (Ty not visited)—m—down R6—F (50).

Rat C. Path m not shown.

1. A—around cylinder—2 (11)—4h—2—Tx (25)—around cylinder—tries to get over cylinder—tries at different points—around on Tx—2h—

over wall at p (70)—down R4 (75)—up R1 (85)—s—down R1 (95)—other room (105)—*taken up* (210).

2. A—climbs around on cylinder—R2h—A—2 (25)—4h—2—Tx (35)—climbs on cylinder—down R2 (60)—under Tx—up R2 (80)—A—around on Tx—over wall at p (120)—near wall at r—6 (140)—4—2—Tx—climbs on cylinder (very excited) (160)—tries its best to get over cylinder—2 (177)—4—6—Ty—down R4 (195)—up R1 (210)—s—down R1—other room (250)—*taken up* (270).

The rat was now trained to get to F from the beginning of m. Procedure the same as for Rat A.

3. A—climbs on cylinder—(15)—Down R2 (20)—R1h—up R2 (28)—wall r h—over wall at p (45)—tries to get up wall directly under m—gets on top of wall from point r (75)—m—down R6—F (93).

4. A—R2h—2 (10)—4—6—Ty—wall r (28)—m—down R6—F (39).

5. A—over wall at p (22)—Ty—wall r (28)—m—F (35).

6. A—washes—tries to get under cage—wall p h—(52)—up at wall r (56) (Ty not visited)—F (65).

Experiment I (8)

In order to test whether or not an habitual response might be easily modified the following experiment was tried. A table made out of a saw horse (s in fig. 11) was placed in a corner that it had never been in before. Food was placed on this table and the three rats were held near the food, but not allowed to eat. The rats were then placed in the doorway. As no experiments had been done for over a week previous to this, it had been usual for the rats to ascend R4 and so reach the food at Tx where they were fed at such times. On this occasion the rats did not go to R4, but instead ran in a large circle about the room. This was as funny as it was unusual. Another saw horse was in the room and all of the rats found it before the right one. Each one climbed up one of the legs and immediately descended again to continue a very active search. Rat B was the first to successfully reach F. Rats A and C soon came to the right saw horse, but as the cardboard extended over one end, only two of the legs made a successful ascent possible. Rats A and C both tried the impossible legs and from there went back and tried the other saw horse again. Both rats then went up R4 to Ty and looked in the direc-

tion of the food. Both again descended and tried the wrong legs again. Rat A next tried a different leg and reached F. Rat C again tried the first saw horse. It was then taken up, again shown the food, and then pushed down one of the legs. With the other two rats it was placed on Tx. All went down R4 and directly up one of the legs of the saw horse to F. Rat C, however, had difficulty. It went to the right leg, but could not climb up

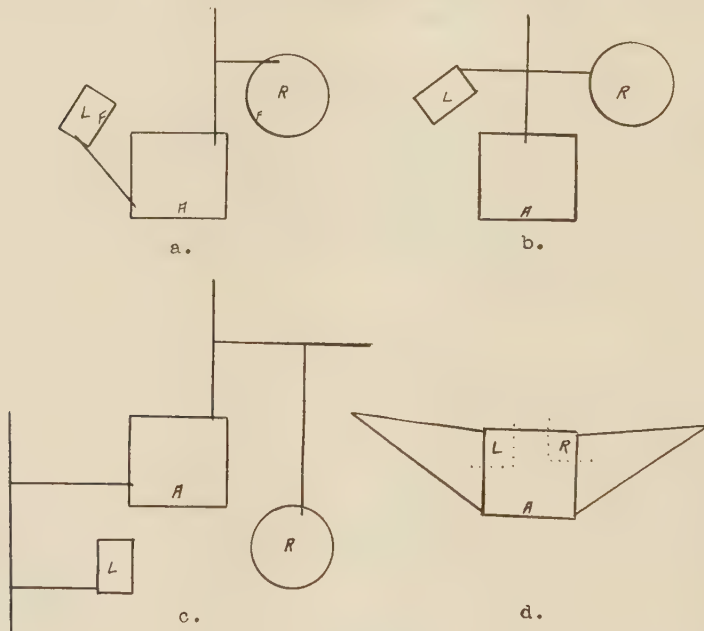


FIG. 12

(perhaps too tired). It would get half way up and fall down. After three such attempts a ringstand was placed near one of the legs and immediately it was used.

Experiment J (9)

In a series of over 20 "set-ups" there were two paths leading from table A. One of the paths led to table R the other to table L. The food was sometimes placed at L and sometimes at R.

With the aid of the light stimulus the rat could know the position of the food and so the problem remained for the rat to choose the path that led to the food on the basis of a cue from the light. Tables R and L were always 30 cm. from table A so that the location of the food was obvious. The light was always placed on R or L as near to table A as possible.

In figure 12 four typical "set-ups" are shown and only the results of these are given. The purpose is to bring out the diffi-

TABLE 18
Stimulus-light present

SET-UP	RAT	T	V	E	Ea	E/T	E/V
a (No. 8)	A	21	10	5	1	0.238	0.500
	B	27	12	5	1	0.185	0.417
	C	32	16	6	1	0.187	0.375
b (9)	A	24	13	4	3	0.166	0.308
	B	24	12	7	3	0.292	0.583
	C	15	8	5	1	0.333	0.625
c (7)	A	21	14	6	5	0.285	0.428
	B	18	8	8	3	0.444	1.000
	C	13	5	6	1	0.461	1.200
d (27)	A	17	10	3	2	0.176	0.300
	B	17	10	4	4	0.235	0.400
	C	17	10	7	6	0.412	0.700
Average.....		20.5	10.7	5.5	2.6	0.285	0.570

culty that the rat may have in keeping two paths separate. The difference in difficulty for different "set-ups" of this kind is of interest, but more data are necessary before conclusive results can be given.

To test responses from chance or other cues, results without the stimulus-light at R and L were also obtained.

Preceding each experiment the rat was permitted to explore the "set-up." In the test it was placed at point A facing forward.

The light with the food was varied in no regular order between tables R and L (as R-L-R-R-L-L-L-R-R-L).

Results: Regarding the behavior of the rats it might in general be said that the rats usually went from A to the point on the table nearest R or L, depending on where the food and light were. From this point they took one or the other path. In “set-ups” such as b in figure 12, the rat did not return to table A in case it went to the wrong table, but took the direct route to the correct table. Table 18 gives the number of trials (T), variations (V) or the number of times the light is changed from R to L and from L to R, errors (E) or the number of times the rat goes to the table without the food, Ea or the number of errors made directly after a variation, E/T (errors divided by trials), an E/V (errors di-

TABLE 19
Value of E/T and E/V

SET-UP	RAT	WITH LIGHT		WITHOUT LIGHT	
		E/T	E/V	E/T	E/V
e	A	0.320	0.615	0.458	0.917
	B	0.366	0.786	0.545	1.091
	C	0.370	0.769	0.435	0.909
f	A	0.166	0.308	0.435	0.933
	B	0.292	0.583	0.500	1.100
	C	0.333	0.625	0.650	1.182
Average.....		0.308	0.614	0.504	1.022

vided by variations) for each rat in four typical “set-ups” in which the light stimulus accompanied the food. Table 19 gives the value of E/T and E/V for two “set-ups” with and without the stimulus-light present. This gives one a means for comparing these values in a situation where knowledge can be applied with a situation where it can not be applied.

Thus the light is a cue for determining the response, but is not adequate enough to make for perfect responses. Without the light, the responses are purely chance.

Experiment K (10)

In the preceding experiment it was found that errors were made by the rat when it had to choose between two possible routes

to food. In this experiment the two routes were of unequal length and the purpose was to see if more errors were made on one pathway than the other. Diagram a in figure 12 is a typical example of this type of "set-up." In some of the cases the short path was to the right, in others to the left.

Table 20 gives the value of E/T and E/V and the ratio between errors made on the short and long paths. The last two

TABLE 20
Ratio between errors made on short and long paths

SET-UP	RAT	E/T	E/V	ERRORS		SIMILAR SET-UP. PATHS EQUAL	
				Short	Long	Right	Left
No. 8	A	0.238	0.500	4	1	4	2
	B	0.185	0.417	5	0	3	5
	C	0.187	0.375	5	1	4	2
No. 10	A	0.320	0.615	6	2	2	3
	B	0.366	0.786	6	5	1	0
	C	0.370	0.769	7	3	1	2
No. 10a No light	A	0.458	0.917	11	0		
	B	0.545	1.091	8	4		
	C	0.435	0.909	6	4		
No. 2	A	0.235	0.800	3	1	4	5
	B	0.444	1.000	4	0	3	4
	C	0.187	0.750	2	1	3	4
		0.331	0.744	67 75.3%	22 24.7%	25 48.1%	27 51.9%

columns of the table give the ratio between right and left paths which are equal in length, but are similar in arrangement to the "set-up" with the short-long pathways.

In every instance more errors were made on the shorter pathway than on the longer. E/V is somewhat larger for these "set-ups" than for those of experiment J, being 0.668 if "set-up" 10a is excluded. The relationship between errors made on the short path and those made on the long path is about the same for 10a (75.8 per cent of the errors being made on the shorter path) as for the "set-ups" which had the stimulus-light present.

Experiment L (10 continued)

To test the importance of frequency in determining which of two paths will be chosen in the type of experiments just described, one of the paths was given twice as many repetitions as the other (i.e., the food and light were on one table twice as often as on the other). For one rat, table R was favored, for another table L, and for the third the repetitions were left equal on tables R and L.

The experiment ran for four successive days, two "set-ups" being used for two days each. In four preceding and four following "set-ups" the frequency was the same for the two tables.

TABLE 21
Frequency for R and L varied

SET-UP	AVERAGE FOR 4 SET-UPS FOR CONTROL BEFORE TEST	AVERAGE FOR 4 SET-UPS FREQUENCY TEST		AVERAGE FOR 4 SET-UPS, CONTROL AFTER TEST
		Control, rat A	Frequency varied, rats B and C	
Trials.....	18.0	14	16	16.7
Variations.....	10.2	8	8	9.3
Errors.....	6.3	6.5	6	5.7
Ea (errors directly after V)...	3.3	4	2.6	3.4
E/T.....	0.344	0.464	0.367	0.337
E/V.....	0.617	0.815	0.734	0.603
Ea/E.....	0.526	0.615	0.433	0.596

These served as control experiments. In each critical experiment the food was an equal number of times at R and L for rat A, 11 runs at R and 5 runs at L for rat B, and 5 runs at R and 11 runs at L for rat C. The same table was always favored for the rat throughout the four days, so that if continued increased repetitions on one side had an effect, it would be brought out.

The results are given in tables 21 and 22.

The third column of table 21 gives the values for the critical tests. They show an increase in error over the control tests (columns one and four), but rat A, used as a control in these same "set-ups," also shows an increase in errors. Hence this increase in error does not seem to depend on the factor of frequency. It is also important to note that the ratio of errors made directly after a varia-

tion to the total number of errors, (Ea/E) has not increased, rather it has decreased.

Thus when the food was obtained twice as often on one table as on the other for rats B and C in "set-ups" 24 and 25, it in no way increased the tendency for the rats to favor that side. In

TABLE 22

SET-UP	RAT A				RAT B				RAT C			
	Right		Left		Right		Left		Right		Left	
	E	Ea	E	Ea	E	Ea	E	Ea	E	Ea	E	Ea
	Frequency equal for all rats											
No. 20	3	2	3	2	3	1	3	1	4	2	5	2
No. 21	4	3	4	2	5	2	2	1	5	3	5	3
No. 22	5	2	2	2	5	2	1	0	4	2	3	2
No. 23	2	1	1	1	2	1	0	0	3	2	2	1
	14	8	10	7	15	6	6	2	16	9	15	8
	Frequency equal				2 Right:1 Left				1 Right:2 Left			
No. 24	4	3	4	2	4	3	5	2	4	3	3	2
No. 24	1	1	6	4	1	0	5	2	4	1	2	2
No. 25	3	1	3	1	1	0	3	2	4	0	3	2
No. 25	2	2	3	2	1	0	2	0	3	0	2	2
	10	7	16	9	7	3	15	6	15	4	10	6
	Frequency equal for all rats											
No. 26	5	3	2	2	5	4	3	1	4	3	2	1
No. 27	1	1	2	1	2	2	2	2	3	3	4	3
No. 28	3	1	0	0	3	2	0	0	4	1	0	0
No. 29	6	3	2	2	4	2	2	0	5	1	4	3
	15	8	6	5	14	10	7	3	16	8	10	7

fact it seemed to cause them to favor the side where the food was less often found. See table 22.

Experiment 6 (5)

The problem here was to see whether or not a rat can choose a direct route to food without first trying out certain paths and then eliminating one of them. De Camp (1) has shown that if there are two possible routes to food, the shorter will finally be favored.

The problem of choosing the shorter of two routes, without previously having run one or both in the form required in the test, involves a knowledge of the situation as a whole and it is this point that is to be determined in this experiment.

Figures 13a, 13b, and 13c show the three "set-ups" that were used. The rat in each case was taught the way from A to F. As there were two different paths to F the rat was first allowed to go one way and then the other. They were forced to alternate their route because one of the routes was always blocked by the hand of the experimenter. In the first two "set-ups" this was the only way the rat had of learning the maze as a whole, but in 13c the rat was allowed to explore the "set-up before the experiment. Tables X and Y were just parts of the pathway during the learning series, but in the test the food was placed at X for half of the rats and at Y for the other half. The following day this was reversed for the two groups. The rat after having learned the way from A to F during the learning series was tested as follows: Food was placed at X or Y and the rat put there to eat. (It was seen that the rat wandered around enough at this point so as to be able to recognize where it was.) Then it was put at F. As there were two possible routes from F to either X or Y, one had to be selected. After two trials starting from F, each rat was tested starting from A.

Table 23 gives the results for the three "set-ups." Each "set-up" was used for three or four days. One group of rats was fed at X one day and Y the next, the other group was fed at Y the first day and X the next. In order that one day's test might not interfere with the test on the following day, the rats were allowed on the maze before the next day's test.

The learning of the maze for the three "set-ups" was as follows: "Set-up" 13a, 15 runs each way over a period of 4 days, 13b, 11 runs each way over a period of 3 days, and 13c, 13 runs each way, spread over a period of 4 days (in addition to being on the maze several hours each day before the test).

On the third run the rats were placed at A, the food remaining where it had been for the other 2 runs. The results are given in table 24.

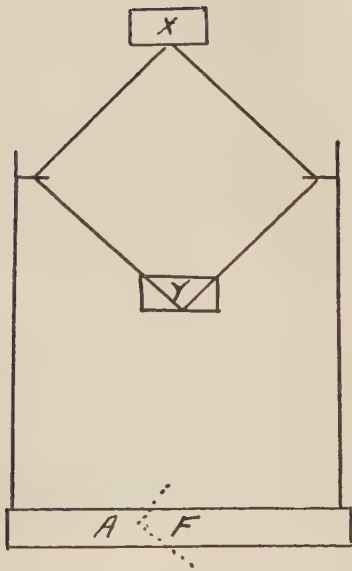


FIG. 13A

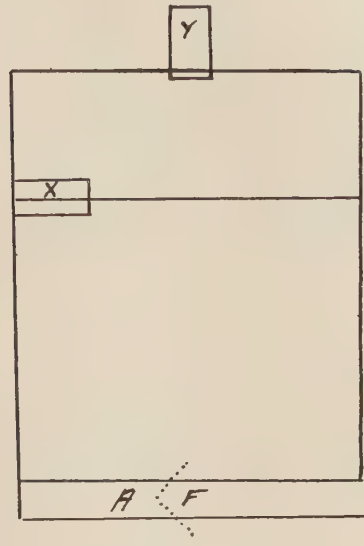


FIG. 13B

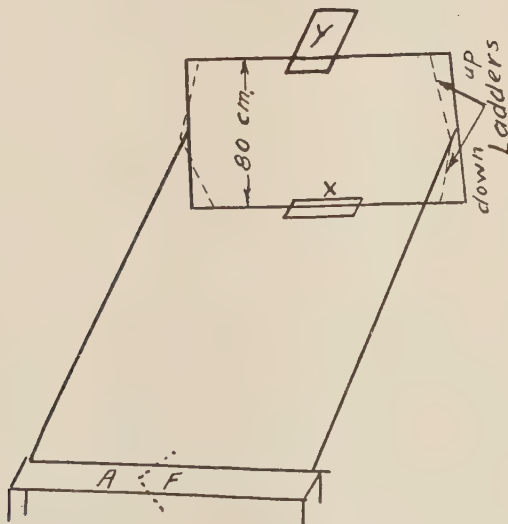


FIG. 13C

TABLE 23
Fed at X or Y. Started at F.

SET-UP (DAY)	NUMBER OF RATS GOING					
	Direct route to point fed (X or Y)		Indirect route to point fed (X or Y)		To A	
	First run	Second run	First run	Second run	First run	Second run
17a (1)*	6	7	1	0	0	0
(2)	6	7	1	0	0	0
(3)	6	6	0	0	0	0
(4)	6	6	0	0	0	0
17b (1)*	3	7	4	0	0	0
(2)	6	6	0	0	0	0
(3)	5	6	0	0	1	0
17c (1)*	6	7	0	0	1	0
(2)	5	7	2	0	0	0
(3)	7	7	0	0	0	0
(4)	6	7	0	0	1	0
Total.....	62 85%	73 100%	8 11%	0 0%	3 4%	0 0%

* There was always a hesitation before the junction at which the rats had to choose between two paths. This occurred for the first run of each new maze and always disappeared on the second run.

TABLE 24
Fed at X or Y, started at A

SET-UP (DAY)	DIRECT ROUTE	INDIRECT ROUTE	TO F
17a (1)	6	0	1
(2)	7	0	0
(3)	6	0	0
(4)	6	0	0
17b (1)	6	1	0
(2)	5	1	0
(3)	3	3	0
17c (1)	6	1	0
(2)	6	1	0
(3)	7	0	0
(4)	7	0	0
Total.....	65 89%	7 9.6%	1 1.4%

TABLE 25
Distribution of errors

	RAT 44	RAT 46	RAT 47	RAT 48	RAT 49	RAT 50	RAT 51	TOTAL
Starting from F.....	2	0	2	0	5	0	2	11
Starting from A.....	1	2	0	0	1	3	1	8

The distribution of the errors among the rats is given in table 25 (an error being the taking of the indirect route).

Experiment 7 (6)

This experiment is a slight modification of experiment 6. There were 3 possible routes to food (fig. 14), 2 of equal length and one slightly longer. The rats were trained to go from A to F by way of the 2 shorter routes and were given alternately 7

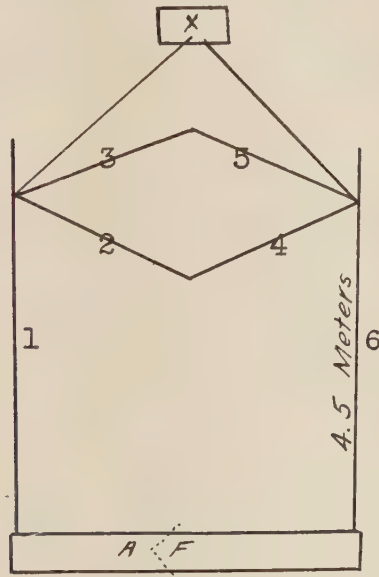


FIG. 14

repetitions on each way. The learning period consisted of the 2 days preceding the test. Several hours before the runs each day, the rats were allowed to explore the maze. Thus any knowledge of the longer pathway and X had to be gained during the exploration period. In running the maze during the learning period there was no tendency to take the longer route.

In the test, the food was placed at X and each rat allowed to eat. (The rats had been on the maze wandering around, up to the time of the test.) The rats were then individually placed at

A. Almost immediately they started on the pathway. Of the 7 rats, 4 went directly to X. The other 3 (rat 46, 49, and 51) went to F by way of the path lying in the direction of X (A-1-3-5-6-F) and from F went directly to X. On the second run all rats took the direct route to X. On the third run each rat was placed at F and all went the most direct way to X.

The following day the rats were fed at A (being on the maze 15 minutes before the test) and then started from F. Four rats took one of the shorter routes to A, three (rats 47, 49, and 51) went by way of X, but without stopping at X. On the 2nd run all but 49 took one of the shorter routes, and 49 took a shorter route on the 3rd run. (Four going F-6-5-3-1-A and three F-6-4-2-1-A.)

Experiment 8 (7)

This experiment is in essentials a repetition of experiment 7 except that there were but two routes to F from A, one long and one short. The rats were allowed on the maze before the experiment. When the light and food were placed at F, all rats except 49 and 51, took the shorter route from A to F. Rats 49 and 51 took the shorter route thereafter. On two days a total of 16 runs were made from A to F by each rat, the rats always taking the shorter route, except as above noted.

On the third day the food was placed at a point X part way along the longer route. The rats were then placed at X and allowed to eat. In the test the rats were placed at A. Three of the rats (46, 48, and 50) went to F and from there directly to X, 3 rats (44, 47, and 49) went directly to X by the shorter route, and one rat (51) took the longer route, but did not go to F. On the second trial all rats went the short way to X. Placed at F in the third run all rats took the most direct way to X.

During the next 8 days the shorter path (from A to food at F) was run 64 times making a total number of 80 runs from A to F. The rats were allowed to explore the maze about every other day before the runs. At the end of this period the rats were again tested by placing the food at X. Only one of the 7 rats (rat 48)

made an error by going to F from A. From F it then went directly to X. Three of the rats made a slight hesitation before going the direct route to X. Rat 50 made an interesting response. It almost passed by the corner leading to X to go the habitual way, then suddenly stopped short and went to X. Starting the rats from F in the second run, all rats went directly to X.

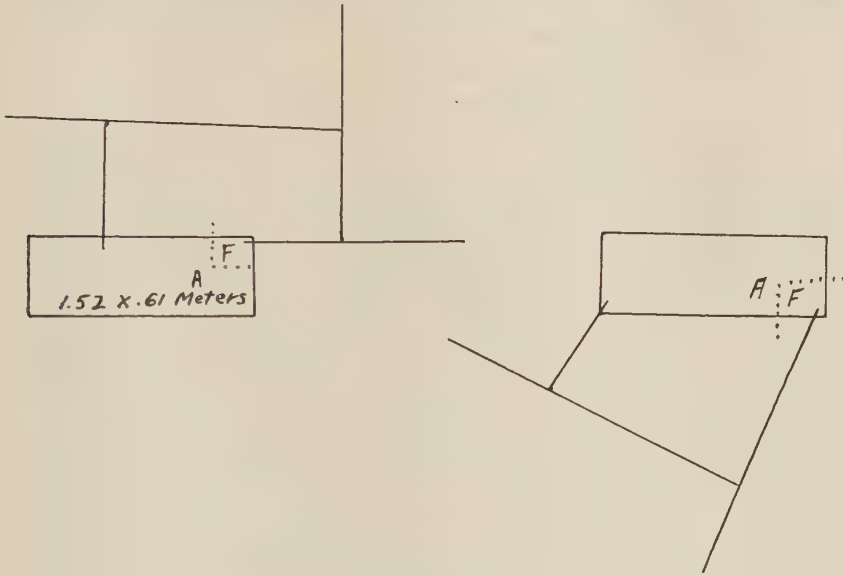


FIG. 15

Experiment 9 (9)

If a rat is placed on a table next to food which is inaccessible because of a wire cage, and if a simple pathway leads from the table around to the food, will the rat choose the turns that lead in the direction of the food?

To test this, 5 "set-ups" were used, typical examples of which are given in figure 15. Each junction is a "T," the rat can either go right or left, one arm leads in the direction of the food the other away from it. Two of the "set-ups" had 3 junctions, the other three had 2 junctions.

The rat was placed at the food and allowed to eat before the test so that it would know of the position of the food. Six rats were used in the tests.

The results show that the rat knew of the food behind the cage in that it tried first to reach the food directly by climbing about the cage. When the pathway was taken, however, there was no tendency to take the turn that led toward the food, the choice made being entirely a matter of chance.

IV. INTERPRETATION OF RESULTS

Experiment A brings out the behavior of rats when they are presented with a problem for the first time in which they have an opportunity to apply their knowledge of a certain territory on the one hand to their knowledge of a pathway on the other, as a means for getting food. At first signs of activity at the point nearest the food and a tendency to remain in that vicinity are observed. However, as soon as the wall is scaled, the running back and forth ceases and the activity continues in one direction. The rat seems to be going somewhere. The average time between beginning to scale the wall and arriving at the beginning of the pathway b, is 18.3 seconds. As this time drops to 5 seconds in the second run and as the second run is perfect enough to be regarded as the minimum time necessary, the time lost in the first attempt is over 13 seconds. In part, this lost time can be accounted for by the difficulty that the rats had in getting to point b for the first time (b being inside the starting box), and in part by the fact that a first solution is not as efficient and fast as it is after one repetition even though the solution may be a unitary whole. The observable difference in the behavior before and after scaling the wall was obvious.

Experiment B (fig. 2) brings out striking differences in the behavior of rats with and without a knowledge of the pathway b-F. If point b were come upon by random wandering around, then the behavior of rats with and without knowledge of pathway b-F should be the same. If previous knowledge of b-F plays a part in the behavior of some of the rats in the solution of such a

problem, then differences should appear. Table 1 shows decided differences in the behavior of the two groups of rats. For rats not familiar with b-F there is, at first, a great hesitancy in leaving the starting table. The activity in the vicinity of the cage continues for a much longer time. For 2 rats with a knowledge of b-F it is 25 seconds and 15 seconds, for rats without this knowledge it is 103 seconds, 180 seconds, and 135 seconds. In the first few experiments this difference is important, but after the rat gets used to taking a round-about path such marked differences are not found (the rat begins looking for a pathway whether or not he knows where it is).

When the rat no longer tries to go directly to the food one of three possible explanations can be given. (1) the solution has occurred to the rat, (2) the rat gave up and is leaving the scene for the time being, or (3) greater excitation or failure in the immediate vicinity is causing the activity to spread over a larger region. Further observation will aid in determining which of the explanations is valid.

Hesitations before paths leading from the table indicate a reluctance for leaving the food. The fact that these paths have been visited before the experiment has given the paths negative values and so reduces the likelihood of the third possible explanation. In the case of the rats without knowledge of b-F such hesitations are present, but not in the case of the rats with knowledge of b-F.

If the rats leave T and do not return for some time there is reason to believe that the rat is no longer actively seeking food. If, however, it tries out many paths there is reason to believe that it is actively seeking a way to food. The taking of the wrong path means that this knowledge is incomplete. It might be that the knowledge of a path leading from one of the tables is determining the behavior and that the path to the particular table is not definitely known. If the paths leading from the table are taken in succession, without a returning to A after each trial, the fact that the rat is seeking a certain path is made probable. The results show that the rats with a knowledge of b-F are actively seeking the pathway.

In the first run of the two rats without a knowledge of b-F, the food is not reached after 300 seconds. At the end of this time they seemed to be very inactive. Both rats left the starting table, Rat C showing no signs of returning and Rat B returning only after an absence of 40 seconds. Rat A which had learned the pathway b-F, was at b after 98 seconds, although it first had taken all the paths leading from the table. This rat seemed to be seeking the pathway, but did not know which path to take. Considering that four different paths led from the middle of table T such errors can be expected.

Comparing the second run of rats B and C in which rat B had learned b-F and rat C not, it was found that rat C reached the starting point of the pathway after 135 seconds, or 55 seconds later than rat B. This difference in time was shown in spite of the fact that rat C took the right path by chance on the first trial and rat B made several errors. The fact that errors were made by the trained rats, however, leaves these results open to question.

These results indicate that the second explanation of the three given above, applies to the rats without knowledge of b-F, at least on the first trial. The second trial of rat C may be an example of the third possibility. Rat A in its first run and rat B in its second run overcame the tendency not to take pathways leading from the table, and when they ceased trying to reach the food directly, decidedly seemed to be seeking something definite.

Experiment C shows that the previous visiting of paths leading from the table tends to give them negative values. Thus the rat that was neither familiar with the pathway b-F nor the "set-up" and so had to use "trial and error," found the food as quickly as the rat that was familiar with both and had the opportunity to use insight. The rat that was familiar with the "set-up," but not the pathway b-F, showed a decided tendency to hesitate before the pathways leading from the table. Thus experience of b-F removed the tendency to hesitate which had been established during the exploration.

The rat with no knowledge of any part of the situation is free to investigate everywhere and has no way of knowing that some

of the paths have "blind" ends. It has no negative responses to any of the paths, but instead, as has been shown in the last part of experiment A, there is a tendency to try everything new. For the simple "set-up" used in this experiment the rat with no knowledge of the "set-up" at all, was about as well equipped to solve the problem as the rat that knew enough of the situation to be able to use insight, especially if there were several paths that could be confused.

Experiment 1 gives the results of the rats used in the University of Michigan laboratory in the same kind of problems. Table 3 brings out the marked difference between the group of three rats which has learned b-F and the group which has not. In each of the 7 "set-ups" the time before reaching b is less for the trained group than for the group that was not shown b-F, and in every "set-up" except the first, the time for the slowest trained rat is less than the time for the untrained rat that arrives at b in the least time.

The average time for reaching b, after being placed at A, was 48 seconds for the group that learned b-F and 207.3 seconds for the group that did not. (As the groups were alternated in the different "set-ups" the individual differences of the groups play no part.) On the second run the time for the groups is 13 seconds and 14 seconds respectively or about the same. The difference between the time of the first run and the 13 seconds that were necessary for the run, is the time wasted. For the trained group the time wasted was 35 seconds and for the control group 194.3 seconds.

The errors (the trying out of a round about path that does not lead to food) also show a difference between the two groups. Of three rats in the trained group 1.4 make errors in each "set-up" as compared with 2.9 of the three rats in the untrained group. The number of errors made in each "set-up" was 2 for the trained group and 10.7 for the untrained. As 9 of the 14 errors made by the trained group were made in "set-ups" 1a and 1f and as 5 of the 10 rats making errors in the 7 "set-ups" made them in these 2 "set-ups," the performance of the rats which learned b-F is in general very nearly perfect.

In experiment D (fig. 4) the possibility of a chance solution was reduced to a minimum. From the results there seems little reason to believe that the solution would have been found by the rats not knowing b-F, had the experiment continued even much longer. The rats that learned b-F also had considerable difficulty and reached b only after b-F had been shown several times. Because n had been the true path in an experiment an hour before there was a great tendency to take this pathway in this experiment. This error was slow in being dropped and is unlike the sudden dropping of errors that was found in other experiments.

A knowledge of b-F did not seem to help rats B and C from the beginning. They behaved as if they had not been shown b-F. When the solution was, however, found, it was a complete whole. When the right relations were put together to form a new configuration the solution followed as a unified whole. Partial configurations were as good as nothing. Thus rat B on its fifth trial and rat C on its fourth trial went directly to b after once starting for the floor. Of interest is the fact that rat B showed a reluctance to going into the next room. Even though the beginning of the path was in the next room, leaving the room that the food was in seemed difficult. In Lewin's terminology (Lectures at the University of Berlin) leaving the room that the food was in was leaving the field, but this the rat could not do because it was seeking the food. Rats A and C had no difficulty in entering the next room because, not having learned b-F, they were ready to give up, and leaving the room was an expression of giving up. Rat C having gone to the other room on previous runs had less difficulty in leaving the room after learning b-F.

If there are three different paths leading to food and only one of them is shown the rat, the point whether or not the rat goes to a definitely learned pathway is more clearly brought out. If the rat does not start out for a certain path the chances are two to one that one of the paths not learned will be found. By comparing the results of such "set-ups" in familiar and in unfamiliar rooms it is possible to bring out the differences in behavior in situations where it is possible to reason and where more or less

random seeking is necessary. If the results show decided differences, the possibility of olfaction as a dominant cue is also excluded. In both the familiar and the unfamiliar rooms the pathway is learned, but in one case the starting point of a pathway (b) can be recognized as having a definite position in the room whereas in the other case it can only be recognized when it is come upon by chance. The "set-ups" in Experiment E were used in familiar rooms and in Experiment F in unfamiliar rooms. In one case b was part of a known situation, in the other, part of an unknown situation.

The results in tables 4 and 5 show a marked difference between the behavior in familiar and in unfamiliar rooms. (Fright and curiosity in unfamiliar rooms had been excluded by making the rats accustomed to strange rooms.) In the familiar rooms the rats always took the path they had previously learned, in the unfamiliar rooms, only a third of the time. (On the third run in the unfamiliar rooms the learned path was taken 58 per cent of the time. There was a tendency to change, which was not shown in the familiar rooms.) The average time before arriving at b after once starting (i.e., time spent on the floor) was 12 seconds in the familiar room and 79 seconds in the unfamiliar room. If the time absolutely necessary for the run (time for the second run) is subtracted it is found that only 5.1 seconds were lost in the familiar room as compared with 72.1 seconds in the unfamiliar room. Thus the rat did little or no wandering in the known room, 5.1 seconds being necessary for slight digressions from a perfectly straight line from A to b and for less rapid running.

At times the rats had difficulties in the unfamiliar rooms and returned to A. This never happened in the familiar rooms. The "trial and error" solution is not a continuous whole and often contains new starts.

The strikingly short time on the floor for the second run in the unfamiliar room (13 seconds) shows that the rat after one trial, can take a fairly direct route to b and does not have to retrace its first run either in whole or in part.

The average time before striking out for food (i.e., time before going to the floor) is 46.5 seconds in the familiar room and 51

seconds in the unfamiliar room. (Due to the fact that the rats were used to getting food by an indirect route there was little or no more hesitancy in striking out to find some path to food than there was in starting off for a particular path learned.)

This interval of 46.5 seconds might be regarded as a delayed reaction. This method used in the study of delayed reactions will appear as a separate publication. (Jr. of Gen. Psy.)

Table 7 of experiment 2 gives the results for 6 other rats in the same kind of an experiment. In a familiar region the learned path was taken 82.9 per cent of the time. As 7 errors were made out of 41 cases it is also possible to compare the average time on the floor for the correct with the incorrect runs. Thus the correct runs required an average of 19.4 seconds the incorrect 61.4 seconds. This marked difference in time shows that the rats which did not apply their learning to the solution of the problem, were greatly handicapped.

Table 9 gives the distribution of errors for the individual rats. As rats 44 and 50 made no errors and as rats 48 and 49 made 5 of the 7 total errors it seems that the errors made in this experiment are more a matter of individual differences than of chance.

In table 10 the results of 6 rats for 11 "set-ups" in familiar rooms are given and in table 14 the results for 10 "set-ups" in unfamiliar rooms are given. Here again there is a decided difference between the behavior in the familiar room and that in the unfamiliar room. In the familiar rooms the learned pathway was taken 88.9 per cent of the time and in the unfamiliar rooms 56.7 per cent of the time. The score for the unfamiliar rooms, however, exceeds the 33.3 per cent which might be expected on the basis of pure chance. This means that there was some means of orientation even in the unfamiliar rooms. The fact that in some of the "set-ups" all of the rats took the path learned and in others all took one of the others, means that some rooms were more easily oriented in than others. In general it seemed that in the long narrow rooms with the lights hung in pairs, there was a greater likelihood that the rats would find the path learned than in rooms more nearly square. Thus the rooms for "set-ups" 10a, 10b, 10c, 10h, and 10i were long and narrow. Also the fact as to whether

or not the centers of the rooms were filled with characteristic furniture seemed to play a part in the ability of the rat to orient itself. Rooms for "set-ups" 10a, 10b, 10c, and 10d are of this type.

The "set-ups" in which the rats showed ability in orienting themselves (the "set-ups" in which 2 or 3 of the 3 rats took the correct path) are 10a, 10b, 10c, 10d, 10f, and 10h. The first three fall in both the above lists, 10d and 10h fall in one or the other and only 10f falls in neither.

The "set-ups" in which none of the rats took the learned path are 10g and 9h, both of which fall in neither of the above lists. In the "set-ups" 10e and 10i one of the three rats took the path learned and 10e falls in neither list, but 10i falls in one of them.

Referring to "set-up" 6b in experiment F it is found that this was in a room which also had considerable character. In this experiment the rats did better than in the others, 2 out of 3 going to the path learned.

As "set-up" 9h was in a room before and after the room was familiar (experiments 2 and 3) it makes possible a comparison between familiar and unfamiliar rooms without room differences entering in. The results show that when the room was still unfamiliar no rats took the path learned, but after becoming familiar with it all 3 rats took the path learned. (While the rats were becoming familiar with the room the "set-up" was removed.) The fact that "set-up" 9h was used a second time in no way bettered the results in the second case because all rats went wrongly the first time, and as the same rat was trained on the same path on both occasions the tendency would be to repeat the same error, if there were any memory of the other "set-up" at all. For three further "set-ups" in this room, 2 rats out of 3 took the correct path in two of the "set-ups" and all went correctly in the third.

In experiment 4 it was found that changes in lighting had little or no effect on the rat's orientation. In experiment 5 it was found that the rat could orient itself in darkness if it could come in contact with characteristic objects. The vibrissae seem to be helpful in the recognition of objects, but can be done without.

With no characteristic objects near, the rat can still orient and recognize its position in the light, but not in the dark. The rat cannot recognize the position of a ringstand in a room when it runs the path from the top of the ringstand. Nor is the direction of the run along the path of any use. Experiment 9 shows that a knowledge of the position of the food in no way helps the rat to find a round-about way to food in unfamiliar territory.

Thus a rat seems to be able to orient itself in the larger whole, not by a certain lighting effect, but by use of objects and walls. Direct contact with wall or object gives best results. Vision, though a factor in the orientation of the rat, is not necessary for the rat in dealing with spatial relations. Moving an object which served as a cue causes confusion.

These points very well agree with the points brought out above, that rooms are more easily oriented in if they are long and narrow and if they have filled centers.

Olfaction as a possible cue was checked by changing ringstands after the learning of a pathway in some of the experiments. In no way did this check modify the results and so was given up as unnecessary. If olfaction played an important part then the finding of a ringstand learned in the dark should not depend on its proximity to objects, nor should familiar rooms show less difficulty than unfamiliar ones.

As 3 rats were always shown one of the three pathways and 3 were not shown a pathway, the difference between the trained and the control groups can be compared in both the familiar and unfamiliar rooms. The control group learned no pathway; so it could not take wrong pathways. Comparisons must therefore be on the bases of (1) time before going to floor, (2) time on floor, and (3) the number of rats returning to A after having started on the floor.

In the familiar rooms the average time before going to the floor is 17.4 seconds for the trained group and 22.6 seconds for the control group. In the unfamiliar rooms the corresponding figures are 35.5 seconds and 44.9 seconds respectively. In both cases the trained group starts out sooner than the control group, but the difference is small in both cases. A knowledge of a path helps

very little as to starting time for experienced rats. This starting time, however, is considerably less in the familiar rooms than in the unfamiliar, although once started the activity was as great in the unfamiliar rooms as in the familiar rooms.

The average time on the floor in the familiar room is 11 seconds for the trained group and 73 seconds for the control group; and in the unfamiliar room 88.5 seconds and 92.1 seconds respectively. In the familiar rooms there is thus a decided difference between the two groups, but in the unfamiliar rooms very little if any difference. Thus being familiar with half the necessary knowledge is no better than having no knowledge at all. The large difference only appears with the group that has the possibility of acting intelligently. A knowledge of the room and of the pathway are both necessary parts of the solution. The results show a striking agreement between the three groups in which chance had to be greatly depended upon, even when the circumstances were different in each case, but a striking difference between the groups where an intelligent solution was possible and where it was not possible. The greatest value for the time on the floor for the trained group in the familiar room is less than the smallest time average for the control group in the familiar room as well as for either group in the unfamiliar rooms.

If the times on the floor for correct and incorrect runs are compared differences also appear. In the familiar rooms it was 10 seconds for the correct runs and 14 seconds for the incorrect. Thus, rats taking the wrong path were slightly handicapped even when there were 2 chances for getting a wrong path against 1 for getting the correct path. In the unfamiliar rooms it was 124 seconds for the correct runs and 40.7 seconds for the incorrect. This indicates that the rat is handicapped in the unfamiliar room when it tries to find the learned pathway. (In no case did the rat refuse to take the first path come upon and in the cases in which the rat found the learned path, it found it without wasting time in the vicinity of some other path.) If it is assumed that there are crude cues for orientation in unfamiliar rooms, then the difference in time between correct and incorrect runs becomes clear. The crude cues give the rat a general direction

and vague feelings of familiarity when certain parts are reached, but they are quite insufficient. The rat not using cues starts off in any direction, usually following a wall. As there are three possible routes to food, one direction is about as good as another and at the same time the rat has not the difficulty of adjusting itself to the crude and indefinite cues, but can consistently keep going without retracing its path.

The number of rats returning to A after having definitely started for the pathway also brings out marked differences between the groups. In the familiar room only 2.8 per cent of the rats that were shown a path, returned to A as against 30 per cent of the control rats. In the unfamiliar rooms 23.3 per cent of the rats that were shown a pathway and 40 per cent of the control rats returned to A. The same differences are thus again brought out that were brought out by the measurement of the time on the floor. Rats with no knowledge of either the room or the pathway are the most likely to be confused, but all groups, except the one in which both room and a pathway were familiar, show a high percentage returning to A.

By placing the rats at some point as X on the third run of "each set-up," another check on the rat's ability to use essential relations is applied.

In experiment E all of the rats took the path they had been taking for the first two runs. In each of the 3 "set-ups," however, 1 of the 3 rats went first to A and from there to the pathway. On the next run these rats went directly to the pathway. In experiments 2 and 3 the rat was placed at the point X immediately after three runs from A. The tendency to go from X to A was not present in these experiments, but the rat always went to one of the pathways.

Table 8 (results of experiments on the maze floor) shows that in 87.8 per cent of the cases the rats, when started from X, took the pathway that they had been taking on the first three runs. The time for going from X to the path that the rat had been taking (correct run) was 8.3 seconds and from X to one of the other paths (wrong run) was 13.2 seconds.

On being placed at X in the known rooms, correct runs were

made 94.4 per cent of the time by the trained group. The time for the correct runs was 7.6 seconds and for the wrong runs 17.5 seconds (table 12). The correct path was taken 86.7 per cent of the time by the control group, the average time for the correct runs being 8.6 seconds and for the wrong 11.2 seconds. It is to be expected that the trained and control groups would be much alike because, after finding the way from A to R (ringstand) 3 times, the control rat is no longer at a marked disadvantage, but can also apply its knowledge of the found path to the situation.

Thus in all the above cases, when the rat is started from a point on the floor, the path that is known is taken more often than can be expected by chance. The time is also too short to allow for more than nearly a direct run to the pathway. The wrong runs also need more time in each case.

When started from X in the unfamiliar rooms the correct path was taken 83.3 per cent of the time by the trained group, the time for the correct runs being 30.9 seconds and for the wrong runs 36.6 seconds. The percentage of correct runs is strikingly large, and as the time for the run is quite large it shows that the rat still has considerable difficulty. However, it now has enough landmarks so that after some wandering from the unfamiliar point X it comes upon some familiar object. When this happens one can observe a difference in behavior. The rat seems suddenly to recognize where it is and to adjust itself accordingly. The time for the correct runs is now less than for the incorrect (contrary to the results in starting from A). This indicates that the rat has now learned enough about the new territory so that the seeking of the learned pathway is no longer a handicap. In two cases the rats did not take the wrong R when it was the first one found. They seemed to be looking for some particular pathway. (In these cases the record has been used as if the rat took the first R found.) This refusal to take the first pathway found did not occur in the runs starting from A.

The results for the control group in the unfamiliar room show less adequate adjustment. The correct path was taken 72.4 per cent of the time, the correct runs requiring 39.4 seconds, the wrong runs 29.9 seconds. (In 7 out of 8 cases the time for the

wrong run was less than the time for the correct run.) Rats taking the correct path seem again to be handicapped. Not enough of the environment seems to have been learned to make the taking of the correct path more efficient. The differences in time are, however, slight and only show decidedly that the unfamiliar room is offering difficulties.

As the rats in the control and trained groups were alternated from "set-up" to "set-up" individual differences in the ability of the groups were excluded.

Experiment G clearly shows how proficiently a rat can adjust itself to changing conditions. The behavior of rat C is an unusually good example of what is probably insight. After 260 seconds of "trial and error" near the cage the rat suddenly changes its behavior by starting for the floor and going directly to the ringstand that leads to the desired goal. Only 20 seconds were used to make the trip across the floor. When the rat once started for the floor there was little doubt as to whether it was headed for some particular place or was just wandering about in a "trial and error" manner.

The variability in the runs also shows that a rat does not learn a particular pathway on the floor. It uses the floor to bridge a gap and it makes no difference how it gets to the floor. No particular motor responses are learned, the rat climbs or jumps to the floor and adjusts itself accordingly. The end determines the response and the specific responses can, therefore, be very different in the same situation.

After using the floor in three different "set-ups" it might be expected that the rat would try to use the floor in a situation in which this would not lead to food. To test this the food was placed on the same table and guarded by a wire cylinder as described in experiment H. Rat B, not having been shown the beginning of the pathway that led to food, did as might be expected. For this rat the solution was a matter of "trial and error" and after 136 seconds it went to the floor by way of R2 as it had done in the three preceding experiments.

Rat A having been shown the pathway, could either make an intelligent solution or try to use the floor as it had been doing in

experiment G. It chose not to go to the floor, and that the solution was not a matter of chance is indicated by the fact that the rat tried to get to m directly. It did not come upon m by crawling over the wall, but tried to reach it by jumping up the side of the wall directly under m. Only after several failures did it manage to get on top of the wall by climbing up at one of the edges.

Rat C was not shown the beginning of the pathway and so, like rat B, had to find it by chance if at all. As in the case of rat B, it goes to the floor as in experiment G.

At the end of two unsuccessful attempts to find the way to F, m is shown. On the third run this rat now goes down R2 at the end of 20 seconds, but instead of continuing the solution of the second set-up in experiment G, it checks itself at R1 and is again at Tx, 8 seconds later. It now proceeds with the solution trying, as did rat A, to reach m from the middle of the wall and only using the edge of the wall after several unsuccessful attempts at the middle. This again shows that m was being sought and was not come upon by chance.

As all 3 rats went to m from the Ty side of the table, they were not taking the shorter route to m, Tx being the other side of the wall and the side from which the rats were starting. However, the rats also discovered this, and after two or three trials went to m directly from Tx.

In experiment I the habitual response was modified by merely showing the rats the food in a new position. Knowledge of the new position of the food made the rats seek this new place rather than go to the table where they had been in the habit of finding food.

When two separate pathways lead to food at different times and the food can be obtained by taking one or the other of them according to the indication of the light cue, the rats have difficulty. The results of experiment J (table 18) show that even when the rat uses the light as a cue to the position of the food and is familiar with both the pathways, it cannot always choose correctly. They do choose correctly enough to show that the association between the light and the food is helpful. This is brought out in table 19 which gives the results with and without the stimulus-light

present. With the light absent the choice was a matter of chance and E/T had a value of .504 and E/V a value of 1.022. With the light present these values dropped to 0.308 and 0.614 respectively. For the 4 typical "set-ups" (table 20) these values were even less, being 0.285 and 0.570 respectively.

The fact that errors were made is of interest. It shows that the rat does not mechanically go right or left because of the associations, light right with right path and light left with left path, which may have been set up. When the rat goes to the corner of table A that is nearest the stimulus-light to the right (left), and then turns and takes the left (right) pathway, one can hardly accept a purely mechanistic interpretation even for this type of problem. The difficulty seems rather to be the keeping of the pathways separately associated with the light in one or the other position.

Whether or not the shorter of two pathways is favored can be seen by making the two paths of unequal length. If more errors are made by the taking of the shorter of the two paths preference for the shorter path is shown. (An error being the taking of one path when the food can only be reached by the other.)

The results of experiment K (table 20) show that the shorter pathway is favored, 75.3 per cent of the errors being made by the taking of the shorter pathway when the other should have been taken. The shorter pathway is favored when the light-stimulus is present and when it is not present to about the same extent. Rat A in "set-up" 10a took the shorter pathway first in every run, and when wrong it merely corrected itself by taking the other pathway. As the light-stimulus was not present in this "set-up" the taking of the shorter pathway first was really an intelligent act because it eliminated the shorter of two possibilities first.

If the food is placed twice as often at the end of one of the pathways as at the end of the other, this path will be taken in connection with food twice as often as the other, and from the doctrine of frequency there is reason to believe that this path will be favored. Hence more errors ought to be made on the pathway at the end of which the food is more often found. In experiment L rat A received food an equal number of times on the right and

on the left path; rat B twice as often on the right as on the left; and rat C twice as often on the left as on the right. Tables 21 and 22 give the results of four such tests with the accompanying control tests before and after the critical tests on frequency. The values for E/T and E/V are slightly greater for the critical series than for the two control series. These differences also hold for rat A used as a control. It seems that the difference in the values of E/T and E/V in the critical and control series, are due to differences in the "set-ups" used.

The relative size of Ea (errors made immediately after a variation) is no greater in the critical than in the control tests, but is even less. The value of Ea/E is 0.526 and 0.596 for the two control series, 0.615 for rat A, which was used as a control in the critical series, and 0.433 for rats B and C in the critical series. Thus, the fact that food is more than twice as often at the end of one pathway as at the end of the other, in no way causes the rat to respond more mechanically and to continue to go the way it has been going on the preceding runs.

Table 22 gives the number of errors made to the right and to the left. If the relation "errors to the right divided by errors to the left" is expressed as ER/EL, the three groups of 4 tests each can be compared. (The middle value being the average for the critical tests.)

Rat A ER/EL = 14/10; 10/16; 15/6 or 1.4; 0.6; 2.5

Rat B ER/EL = 15/6; 7/15; 14/7; or 2.5; 0.5; 2.0

Rat C ER/EL = 16/15; 15/10; 16/10 or 1.1; 1.5; 1.6

For rat A the frequency remained constant, hence the fact that the middle value is less than 1 and the end values more than 1 must be due to chance variation. The low value of ER/EL in the critical series is due to one of the 4 tests, the errors in the other three tests being evenly divided. This indicates that chance in the values for this rat plays a great part. For rat B there is the same difference between the middle and end values, but to even a slightly greater extent. As the left is favored in each of the 4 tests there seems to be less of a chance element entering into these results. As rat B was fed twice as often right

as left in the critical series it is to be expected that R should be favored and that the value of ER/EL be greater in the critical series than in the control series. Yet just the contrary is the case. The results for this rat indicate that there is a tendency to equalize the number of times it goes right and left, and as the food is more often to the right it goes left wrongly more often. As rat A showed the same variation to a great extent this tendency to equalize the runs on both pathways might be seriously questioned. That, however, greater frequency of eating right did not cause this rat to make more errors to the right cannot be questioned.

Rat C very evenly divided its errors in the first group of tests. In the critical test the right was favored in each one of the 4 tests. In the last group of tests the right continues to be favored to about the same extent. As rat C was fed twice as often to the left as to the right one should expect the left to be favored. Yet, as in the case of rat B, the opposite side is favored and continues to be favored even in the following group of tests.

It might be argued that more errors are made on the side where food is found less frequently because the food is there only half as often and the possibility of making errors is then two times as great as on the other side. (This of course presupposes that frequency is not a factor strong enough to overcome any chance behavior of this type.) To check this, the first runs only, after each change may be compared. And as recency and frequency are both at an advantage immediately after the change, these runs should decidedly favor the making of more errors on the side on which the food was more often found, the chances for errors now being equal.

The values for EaR/EaL are as follows:

Rat A $8/7$; $7/9$; $8/5$ or 1.2; 0.8; 1.6

Rat B $6/2$; $3/6$; $10/3$ or 3.0; 0.5; 3.3

Rat C $9/8$; $4/6$; $8/7$ or 1.1; 0.7; 1.1

Thus for rat C the left side was favored as might be expected from the doctrine of frequency, yet the results show no greater favoring than for rat A which was used as a control. Rat B, on the other hand, decidedly favored the left side when it should

have favored the right on the grounds of frequency in the critical test. Thus if the food were right for 2 runs, left for 1 run, right for 4 runs, left for 2 runs, etc. in such a way that the right was favored twice as much as the left, there was no more tendency to continue going right after a change in the position of the light than there was to go left. But if the rat received food one time to the left and the light was then changed to the right, there was some tendency to go left again and make an error. These results show that frequency is not a dominant factor in a situation that involves more than mechanical behavior. In fact, increasing the frequency seems rather to set up a counter tendency, that of equalizing the number of runs on both pathways. One might call it a tendency toward symmetry.

In experiments 6 and 7 (University of Michigan) the rats were tested as to their ability to select the most direct or shortest route to food when the food was placed at a certain point on the maze for the first time. They learned some of the mazes by running from A to F, but in others they were also allowed to investigate the maze before each day's runs.

In experiment 6, with the food placed at either X or Y (figs. 13a, 13b, and 13c) and the rat started from F (where it had been fed during the learning period) it might do one of three things; (1) take the direct route to the food at X (or Y) where it had been allowed to eat just before the test, (2) take a more indirect route to X (or Y), or (3) use the backward running associations (if there are any) and go from F to A, providing it did not happen to pass over X (or Y) on its way to A.

If the experience of eating at X (or Y) plays no part in the behavior of the rat when placed at F in the test, 50 per cent of the rats should reach the food by the most direct route; if this experience does modify the response, more than 50 per cent should take this route. In case the direct route was not taken the rat could still show the influence of having eaten at X (or Y) by taking the longer route to X instead of continuing to A.

On being placed at F the rats almost immediately set out for the food. Table 23 shows that the direct route was taken 85 per cent of the time, the indirect route 11 per cent of the time,

and only in 4 per cent of the cases did the rat go to A. On the second run the direct route was taken in every case. The rats going wrongly on the first run corrected themselves, even though they had found a different way to the food.

Started from A on the third run, the well established associations should cause the rat to go to F and by chance alone the food should be reached accidentally in 50 per cent of the cases. Instead the direct route was taken from A to X (or Y) in 89 per cent of the cases, the indirect in 9.6 per cent of the cases, and only in 1.4 per cent of the cases did the associations formed in the learning series dominate and cause the rat to go to F.

In experiment 7 (fig. 14) the food was placed at a point X (in the test run) which was not part of the pathway from A to F as in experiment 5. Hence X was familiar to the rat only through its exploration. On being placed at A in the test run the rats should all continue to F, without passing over X, if the well established associations dominate the rat's behavior. If the knowledge of the position of the food modifies the response, then X should be visited either by the more direct or by the less direct route. If more than half the rats take the most direct route, it means that, in addition to having their response modified, they can choose the more direct route to food without first trying each of them out.

(During the learning series of 14 runs there was no evidence of a tendency to go to F by way of X.)

In the test, 4 of the 7 rats took the direct route from A to X, the other 3 went to F as they had learned to do during the learning series. However, after arriving at F they very soon turned about and went directly to X. On the next run all of the rats took the shorter route to X. Placed at F on the third run all rats went the most direct way to X.

The following day, after being fed at A and started from F, 4 rats took one of the shorter routes to A, the other 3 went by way of X and showed the influence of the previous day's run. Two of the same rats made errors both days.

Experiment 8 is a repetition of experiment 7 except that it has but one instead of two short routes from A to F. In the learn-

ing series the rats naturally favored this shorter to the longer path, and so the shorter path became the habitual path both by preference and by number of repetitions. With the food placed at X in the test run, 3 rats went directly from A to X, 1 went indirectly (longer route), and 3 went to F and from there directly to X. On the second run all of the rats took the shorter route. (The "set-up" used in experiment 8 was different enough from that used in experiment 7 to make it a new situation for the rats.)

Increasing the number of repetitions on the shorter path from A to F up to 80 did not make this pathway more habitual, and a modification of behavior or an adjustment to the changed situation, more difficult. In fact only 1 rat, instead of 3, failed to modify this habitual response and go to X, when fed at X before the test.

Thus the results of experiments 6, 7, and 8 show that the rats can select the shorter of two pathways without first going over each of them and gradually eliminating the longer one. Experiments 7 and 8 show that frequency is not a dominant factor and does not determine the behavior of the rats when the whole situation is known and when responding in accordance with frequency leads to some other than the desired end. Even the rats dominated by frequency in the first run, so adequately adjust themselves on the following run, that one is led to explain the error in the first run as due to lack of attention rather than lack of ability to intelligently modify the habitual behavior.

Due to the fact that rats can successfully select the shorter of two pathways without first trying them out, it seems evident that they must have had the knowledge of the maze as a spatial whole rather than a mere temporal succession of experiences. Relations between any two points in a larger whole cannot be successfully adapted to if all these relations are matters of mere succession. The rat's knowledge of a situation must be comparable to that of visual spatial relations. An ape or a human can adequately respond to a round-about solution which is new, when it has a spatial view of the whole situation. The rat must gain this sort of knowledge of the whole situation by exploring all parts of it with the use of kinaesthesia, touch, and its inade-

quate vision. Vision perhaps plays a part in the rat's orientation, but it does not guide the rat from one distant object to another. A rat can pass within 15 or 20 cm. of a ringstand and not find it. Even a change made in a pathway is noticed only when the rat is directly upon it. If a pathway with which the rat is familiar is shortened, it will invariably cause the rat to run off the end.

It is also of interest to compare the number of errors made by the different rats in the different experiments.

	RAT 44	RAT 46	RAT 47	RAT 48	RAT 49	RAT 50	RAT 51
Experiment 2 (maze floor).....	0	1	1	3	2	0	Not used
Experiment 2 (floor).....	1	2	0	Not used	1	0	0
Experiment 5.....	2	0	2	0	5	0	2
Experiments 6 and 7.....	0	2	1	2	2	1	3
Total.....	3	5	4	5	10	1	5

From the above one might give the rats an intelligence rating.

V. SUMMARY OF RESULTS

The experimental findings show that:

1. Rats can combine the essential relations of one situation with those of another in such a way as to reach the goal which could not be reached by any one concrete experience. They can adequately adjust themselves to a new situation without "trial and error," but with intelligence and insight. The solution is a continuous whole and is directed toward an end (experiments A, B, C, D, E, F, 2, 3, H, 6, 7, and 8).

2. The behavior of a rat varies for the same situation. The end determines the response and the means to the end may vary. (When the floor is used to bridge a gap between two tables, the use of the floor, not the way to the floor or a definite route on the floor, is learned (experiment G).

3. The habitual response is less likely to follow in a new situation in which it does not lead to the goal, than in one which leads to the goal. If the situation is completely known, the rats

can adequately adjust themselves to a change, in spite of the fact that an habitual response is the only one learned in connection with food (experiments H, I, 7, and 8).

4. Rats encounter difficulties in using light as a cue for the differentiation of two pathways. The amount of difficulty depends on the nature of the starting points of the pathways (experiment J).

5. The shorter of two paths (one or the other of which leads to food at different times) is preferred even when a stimulus-light is present to indicate the position of the food (experiment K).

6. If one of two paths which leads to food at different times is more frequently used in connection with food than the other, the distribution of errors is not greater on this pathway than on the other. In fact the other pathway seems to be favored instead, due to a tendency to equalize the runs on both paths (experiment L).

7. Although frequency is a factor in the formation of a habit, it does not determine the rat's behavior when the situation is intelligible or has sense for the rat (experiments 7 and 8).

8. A rat can select the shorter of several routes to food in a known situation without first going over them in connection with food or in any special and invariable order (experiments H, 6, 7, and 8).

9. The knowledge of a situation is spatial and not a series of successive experiences for the rat. When the rat is familiar with a situation, it knows it as an immediate whole (experiments 6 and 7, and indications from the experiments on the floors of rooms).

10. A rat finds its way about a room partly by means of tactual familiarity with objects and partly through the general visual appearance of a room if it has considerable character. Either the visual pattern of the room without contact with familiar objects, or contact with familiar objects in total darkness are sufficient cues for the rat to orient itself (experiments 3 and 5).

11. The lighting condition of the room is unimportant. A room learned under one set of lighting conditions is also known under a different set of lighting conditions and even in the dark (experiments 4 and 5).

12. Having run a maze does not give the rat the position of F in relation with A, although some inadequate cues seem to be present. The poles of the maze resting on the floor are used as a guide (experiment G). Nor does a knowledge of the position of the food help the rat to choose the paths that lead in that direction, if the paths are unfamiliar (experiment 9).

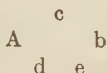
13. Olfaction as a cue plays no part in determining these results. In experiments where it might have been effective it was checked (experiments 3, 5, and J).

VI. THEORETICAL DISCUSSION

The results show that chance and "trial and error" cannot explain the behavior of the rats in solving the type of problems presented in these experiments. Let us then turn to association, in the sense of mere stimulus-response connection, and see whether or not it can explain.

On the basis of associations, which depend on frequency, recency, and intensity, it might be assumed that the rat has associated point A with every other point in the known territory and every other point with all other points. Thus the associations A-b, A-c, A-d, b-c, b-d, etc. may have been formed. From b the rat then learns the pathway to F, forming the association b-F. In the test, the rat being placed at A, goes to b and then to F. Why, on the basis of association, should the rat go from A to b rather than to c, d, e, or some other point, all points being equally well associated with A? The experience of going from b to F must in some way make b stand out. On the basis of the present notion of association, the association A-b cannot be strengthened by the formation of the association b-F. Hence this notion of association is as unsatisfactory as chance and "trial and error" for explaining these results.

Instead of saying that a series of associations are formed it might be said that the rat has a pattern of the whole situation such as



This is the association pattern notion of Shepard and Fogelsonger (11).

The above pattern is formed during the period that the rat is wandering about and investigating. In the learning of the pathway another pattern, b-1-3-5-F, is formed.

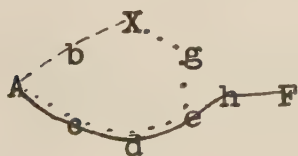
In the test the rat is placed in a situation which is different from the other two. Because of the food at F, point A has a new relation. The rat tries to get from A directly to F. This is a third pattern and dominates during the "trial and error" period when the rat tries to get through or around the cage.

The rat has now experienced three patterns:

- (1) A—F (2) A $\begin{matrix} c \\ b \\ d \quad e \end{matrix}$ (3) b—1—3—5—F.

"A" of patterns 1 and 2, b of patterns 2 and 3, and F of patterns 1 and 3 must become identical. When the solution comes, certain essential parts of patterns 2 and 3 must combine to form the new pattern A-b-F, which is the solution. This is a new combination, a new creation, and is made up of parts of two separate experiences. It is not a pattern that was formed by mere repetition as were patterns 2 and 3. The presence of pattern 1 gives the drive and a certain direction of energy. Patterns 2 and 3 then combine to take its place, A and F having an altogether different relation to each other than they had in pattern 1. The formation of the solution-pattern is the moment or flash of insight.

The following diagram shows the patterns present when the rat chooses the shorter of two possible routes to food without first running them in connection with food.



Pattern a ———

Pattern b - - - - -

Pattern c

Pattern 'a' dominates in the learning series. The rat, having then been fed at X and placed at A, has the possibility of experi-

encing the formation of either or both of two patterns which lead to the food X. Whether pattern b is usually selected because it is simpler than pattern c or whether it is the only one formed cannot be said.

Because a certain pattern has frequently dominated does not make it most likely to dominate in a situation where such dominance does not lead to the goal. Placing the goal outside of the pattern necessitates the formation of a new pattern. The starting point and the end are the determining factors in the formation of a new pattern.

What causes a new pattern to form out of parts of two other patterns is another problem. It may be that the common elements have been made to stand out or become more intense, or it may be a matter of the recognition of essential likenesses and differences as Shepard holds. But that a new pattern, the solution, which is made up of essentials from two other patterns, has been formed seems to have been indicated. The end also seems to be a determining factor as to what the nature of the new pattern will be.

As the combination of two patterns in the solution of a problem is at the bottom of theories of reasoning that make reasoning more than "trial and error," it must be granted that white rats also reason.

The concept of patterns or Gestalten thus seems to be a necessary assumption to explain these complex types of behavior. The fact that a rat can choose the shorter means to an end without previously having reached this end by any of these means, seems to make a pattern concept almost a necessity. A temporal chain is not sufficient, it must be an immediate whole.

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